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Science of Gymnastics Journal (ScGYM®)

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

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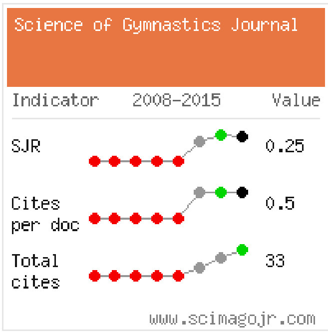
Editorial Office Address
Science of Gymnastics Journal
Faculty of Sport, Department of Gymnastics
Gortanova 22, SI-1000 Ljubljana, Slovenia
Telephone: +386 (0)1 520 7765
Fax: +386 (0)1 520 7750
E-mail: scgym@fsp.uni-lj.si
Home page: http://www.scienceofgymnastics.com



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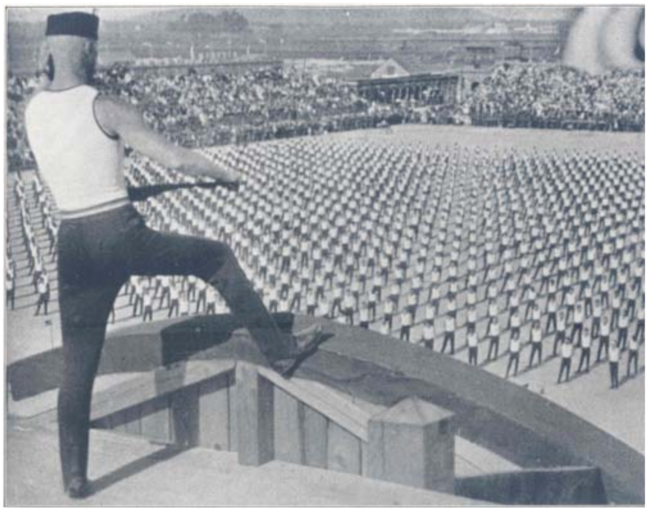

On April 4th 2016, at Faculty of Sport, University of Ljubljana we opened memorial museum room dedicated to the Slovenian father of gymnastics dr. Viktor Murnik. His work is important as with him started education of coaches, he started women gymnastics, established Slovenian Sokol Asociations, enter into FIG, he was gymnast, coach (3rd place with team at OG 1928), scientist, publisher. His heritage is now on permanent display.

The Murnik's room was open by Republic of Slovenia President Borut Pahor.

Dr. Viktor Murnik is saluting participants during WC1922 in Ljubljana

From left: prof. Ivan Čuk- author of museum display, Slovenia President Borut Pahor, Faculty of Sport Dean prof. Milan Žvan, University of Ljubljana Rector prof. Ivan Svetlik, Primož Heinz – National Council, Janez Sodražnik – vice president of Slovene Olympic Committee, Dejan Crnek – president of Slovenian Sokol Union, photo Bogdan Martinčič

From right: Borut Trekman – owner of dr. Viktor Murnik heritage, Miroslav Cerar – Olympic Champion, Tine Šrot – European Championship bronze medalist on vault, Janez Šlibar – coach of Yougoslav team at WC 1970 in Ljubljana – 4th place, Milica Rožman Šlibar – gymnast at OG 1948 and WC 1950., Aljaž Pegan – World Champion, Alojz Kolman - European Championship bronze medalist on high bar, Mitja Petkovšek – World Champion, photo Bogdan Martinčič

EDITORIAL

A few days ago SCOPUS published new values for SNIP, IPP and SJR for 2015. In SNIP The Science of Gymnastics has been upgraded and placed in the second quarter of journals. It is a great improvement! In IPP and SJR, we remain in the third quarter. I met and had talks with Hardy Fink, director of FIG Academy, and Prof. Keith Russell, Chairman of the FIG Scientific Commission. We all agree that we need a history section for our sport. Professor Anton Gajdoš, has been writing 'Historical notes' for our journal about important persons in our sport. But there are many important historic documents that should also be made public, such as documents relating to the foundation of FIG and national federations; how and when national federations entered FIG; documents about previous championships, medals, cups, diplomas; what were the requirements for compulsory and optional exercises and how they looked, etc.

In our previous issue, an error occurred in the names of the authors of article Participation of the Pan-American Gymnastics Union in the 2011 World Gymnaestrada, for which we apologise. The Brazilian researchers lead by Elizabeth Paoliello were Eliana de Toledo, Daniela Bento Soares, Tabata Larissa Almeida, Cintia Moura, Andrea Desiderio, Michele Viviene Carbinatto, Carolina Gontijo Lopes, Bruno Barth Pinto Tucunduva and Marco Antonio Coelho Bortoleto. When sending an article, please make sure that the names of authors in ScholarOne are the same as in those in the cover letter to prevent such errors in the future.

In line with the practice of other journals, from this year onward page numbers continue from the first issue to the third one rather than starting with page one in each new issue.

In August, the Olympic Games in Rio de Janeiro in Brazil will start with our sports, artistic gymnastics, rhythmic gymnastics and trampolining. We hope our sports will continue to be successful in the Olympic family and hopefully some other disciplines can join them in the near future (sports aerobics, acrobatics). With enthusiastic participation of athletes, coaches, managers, researchers, scientists and media support we can succeed.

In this issue there are seven articles. Their authors are from Croatia, Bosnia and Herzegovina, Switzerland, Serbia, Greece, Slovenia and Portugal. Topics are very diverse, including competition result analysis, strength development, injuries in relation to the balance abilities, health gymnastics, gymnastics knowledge evaluation and differences in gymnastics participants' gender.

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

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

Ivan Čuk
Editor-in-Chief

From dr. Viktor Murnik heritage: cup for 4th place for Slovenia at World Championship in Torino 1911, the oldest Slovenian sports team trophy at Worlds

PERFORMANCE ANALYSIS OF FEMALE GYMNASTS' VAULT IN ELITE COMPETITIONS FROM 2008 TO 2015

Sunčica Delaš Kalinski[1], Almir Atiković[2], Igor Jelaska[1], Mirjana Milić[1]

[1]University of Split, Faculty of Kinesiology, Croatia
[2]University of Tuzla, Faculty of Physical Education and Sport, Bosnia and Herzegovina

Original article

Abstract

*Vault is an apparatus that slightly differs from other in women's artistic gymnastics in the way of judging, duration of performance, but also in the requirements for certain biomotor abilities of the competitors. Accordingly, the question of number of competitors in the Vault Qualifications arises. Of all the major competitions in the period from 2008 to 2015 only at the competitions that were Individual All-Around Finals and Individual Event Finals (WC2009 and WC2013) a high percentage of Vault Qualifiers (WC2009 = 81.03%; WC2013 = 90.90%) has been identified. At other competitions (OG2008, WC2010, WC2011, QOG2012, OG2012, WC2014, WC2015) only approximately 20% of the elite competitors competed Vault Qualifications. Furthermore, due to identification of the impact of Competitor type (Vault Qualifiers or All-Around competitors), Competition (OG2008, WC2009, WC2010, WC2011, QOG2012, OG2012, WC2013, WC2014, WC2015) and their interaction with vaults Difficulty Scores, Execution Scores and Total Scores between-between 2*9 factorial ANOVA was applied. Finally, it was concluded that biomotor skills and competitors' selected tactics probably generated the obtained significant differences. The results should be guidelines in planning and programming of training sessions for female elite competitors who aspire towards the Vault Finals.*

Keywords: *female, artistic gymnastic, vault, development.*

INTRODUCTION

Women Artistic Gymnastics (WAG) is a multidisciplinary sport where the All-Around competition (competition on all four apparatuses: vault, uneven bars, balance beam and floor) is considered to be the basic one. However, in accordance with their abilities, tactics and competition format, gymnasts have the possibility to choose to compete or not on all four apparatuses. Major competitions in WAG (Olympic Games and World Championships) are divided into several phases: Preliminaries (C-I competition), Individual All-Around Finals (C-II competition), Individual Event Finals (C-III competition) and Team Finals (C-IV competition), which are held on different days. Among those, the C-I competition is probably the most important event since all individual athletes and teams compete in it and the scores from that competition determine who qualifies for other competitions.

The result in WAG competitions comes from judges' evaluation. In 2006, a new way of scoring was introduced in artistic gymnastics and in 2009 (FIG, 2009) it was slightly modified. According to it, *Final Score* (*FS*) on each apparatus is obtained by summing up the *Difficulty Score* (*DS*; the sum of the highest 8 difficulties, compositional requirements and connection values) and *Execution Score* (*ES*; deductions for errors in execution and artistry are added together and then deducted from 10.00P). Certain exceptions from this model of evaluation exist in judging Vault Qualifications and Vault Finals. Namely, each vault is presented in the Table of Vaults (CoP), together with its own number and predefined *Difficulty Value* (*DV*). Before performing each vault, according to the CoP (FIG, 2009; FIG 2013), a gymnast is responsible for flashing the intended vault number. In this way the judges, before the vault performance, know the *DV*, i.e., the *DS* of the vault. After the vault performance, judges need to: 1) determine whether the announced vault was performed; 2) determine whether the *DV* of the performed vault equals the *DV* of the announced vault; 3) determine the *ES* of the performed vault.

Although WAG CoP for the vault reflects certain changes in each Olympic cycle, it generally prescribes the following: a) gymnasts in Preliminaries must perform one vault or two vaults if they want to qualify for the Vault Finals; b) the 1st vault score counts toward the Team and/or All-Around Total Score; c) in Preliminaries, with the aim of qualifying for the Vault Finals, gymnasts need to perform two vaults that show different repulsion phase (take off position from the vaulting table) (FIG, 2009), respectively two vaults from different groups and with different second flight phase (FIG, 2013); d) *FS* determines the rank of the gymnasts; e) *FS* in Preliminaries and Vault Finals is obtained by the simple average of the two vault's scores performed: $\mathrm{FS} = \frac{\mathrm{FS\,VT1} + \mathrm{FS\,VT2}}{2}$; e) top eight *FS* (achieved during Vault Qualifications at C-I) qualify for the Vault Finals (maximum of two gymnasts per national team).

Major deduction for vault execution was introduced in CoP 2009 - 2012 (rules for landing in different places in/or outside of the Corridor Line) and has been slightly changed in WAG CoP 2013 – 2016.

As movements, vaults are very complex motor skills that need to be performed in a very short time (most vaults, on average, do not last more than 7 seconds) and differ in time structure of one or more of 7 vault phases: approach, flight to springboard, springboard actions, the 1st flight phase, support, the 2nd flight phase and landing (Čuk & Karácsony, 2004; Atiković, 2011; Atiković, 2014). Taking this into account, the WAG CoP have classified all vaults into five groups: Group 1 – Vaults without salto (Handspring, Yamashita, Round-off) with or without longitudinal-axis turn in 1st and/or 2nd flight phase; Group 2 – Handspring forward with or without 1/1 turn (360°) in 1st flight phase – salto forward or backward with or without longitudinal-axis turn in 2nd flight phase; Group 3 – Handspring with ¼ - ½ turn (90° - 180°) in 1st flight phase (Tsukahara) – salto backward with or without longitudinal-axis turn in 2nd flight phase; Group 4 – Round-off (Yurchenko) with or without ¾ turn (270°) in 1st flight phase – salto backward with or without longitudinal-axis turn in 2nd flight phase; Group 5 – Round-off with ½ turn (180°) in 1st flight phase – salto forward or backward with or without longitudinal-axis turn in 2nd flight phase (FIG, 2013). Regardless of the group that they belong to, judges evaluate only four phases of vaults: the 1st flight phase, the repulsion phase, the 2nd flight phase and the landing.

Compared to other apparatuses, the vault is the most analysed apparatus (Prassas, Kwon, & Sands, 2006). Čuk and Karácsony (2004) and Atiković and Smajlović (2011) presented the results of various authors who analysed different stages and characteristics of vaults.

Beside those studies, there are studies that analysed the quality of judging on the vault. Research conducted in Men's Artistic Gymnastics (Leskošek, Čuk, Karácsony, Pajek, & Bučar, 2010; Bučar Pajek, Forbes, Pajek, Leskošek, & Čuk, 2011; Leskošek, Čuk, Pajek, Forbes, & Bučar Pajek, 2012; Atiković, Delaš Kalinski, Bijelić, & Avdibašić Vukadinović, 2012; Perederij, 2013) have determined that: a) the vault is the most valuable apparatus for All-Around gymnasts; b) it is the easiest apparatus on which to obtain a high *DS* (Čuk & Atiković, 2009) and the highest *ES* (Atiković, Delaš Kalinski, Bijelić, & Avdibašić Vukadinović, 2012; Atiković, Delaš Kalinski, Kremnicky, Tabaković, & Samardžija Pavletič, 2014).

Previous study in WAG have determined that the Vault and Floor Finals were sessions with the highest scores and the lowest scores dispersion and it has been suggested that they should be inspected with special care in future judging analyses (Bučar et al., 2012). Another WAG study analysed the differences between junior and senior female gymnasts. It determined that senior gymnasts generally perform vaults better than junior gymnasts. They ascribed this to the increased anthropometric characteristics of senior compared to the junior gymnasts (Erceg, Delaš Kalinski, & Milić, 2014, Delaš Kalinski, 2015).

The authors of this paper posed the problem of the paper on the empirical fact that only a small number of gymnasts compete two vaults, with the aim of qualifying for the Vault Finals. Accordingly, the first objective of this study was to determine the proportion of women gymnasts (from all C-I competitors) that compete two vaults. The second objective was to identify the impact of *Competitor type* (Vault Qualifiers or All-Around competitors), *Competition* and their interaction (*Competitor Type*Competition*) with competitors scores achieved in C-I competitions, at all major competitions, from 2008 to 2015.

METHODS

The sample included all the elite senior women gymnasts who participated in C-I competitions at the Olympic Games in 2008 and 2012 (OG2008, OG2012), at World Championships in 2009, 2010, 2011, 2013, 2014 and 2015 (WC2009, WC2010, WC2011, WC2013, WC2014, WC2015) and in the Qualification Tournament for the Olympic Games in 2012 (QOG2012). Elite competitors were divided into two groups (All-Around competitors and Vault Qualifiers) depending on their participation in All-Around or in both All-Around and Vault Qualifications.

The variable sample is presented by: a) a set of *Difficulty Scores* (*AA VTDS*), *Execution Scores* (*AA VTES*) and *Final Scores* (*AA VTFS*) obtained for the performance of the 1st (and the only) vault of All-Around Competitors in C-I competition; b) by a set of *Difficulty Scores* of the 1st and the 2nd vault (*VTQ VT1DS/VT2DS*), *Execution Scores* of the 1st and the 2nd vault (*VTQ VT1ES/VT2ES*) and *Total Scores* of the 1st and the 2nd vault (*VTQ VT1TS/VT2TS*) of Vault Qualifiers in C-I competition. For the purpose of this study, *Total Score* (for Vault Qualifiers) presents a score of each vault, while *Final Score* for Vault Qualifiers (*VTQ FS*) is the average of the two vaults performed.

The values of the mentioned scores were taken from the Internet. Reliability of those scores, that are the results of expert judging, have been established as generally satisfactory in previous studies (Bučar, Čuk, Pajek, Karácsony, & Leskošek, 2012; Bučar Pajek, Čuk, Pajek, Kovač, & Leskošek, 2013). Detailed descriptive parameters of the analysed variables, from the same competitions, have also been presented in some previous studies (Massida & Calo, 2012; Leskošek, Čuk, & Bučar, 2013; Atiković, Delaš Kalinski, Kremnicky, Tabaković, & Samardžija Pavletič, M., 2014; Erceg, Delaš Kalinski, & Milić, 2014).

Data analysis included calculations of Mean±Standard deviations. Significance of differences between the observed frequencies of performed vaults was also presented. Data was checked for univariate and multivariate outliers. None was found ($p > .05$). Due to identification of influence of factors *Competition* (OG2008, WC2009, WC2010, WC2011, QOG2012, OG2012, WC2013, WC2014, WC2015) and *Competitor Type* (All-Around competitors or Vault Qualifiers) and their interaction with *DS*, *ES*, and *FS/TS*, between-between 2*9 factorial ANOVA was applied together with Bonferroni post hoc correction when needed. (Partial) η^2 was used for effect size assessment. Data was considered significant if $p < .05$. All the calculations were performed using the Statistica 12.0. software package (StatSoft, Tulsa, OK, USA).

RESULTS

The number of female competitors who, at C-I competition, competed only All-Around (and performed only one vault) and those who competed Vault Qualifications (and performed two vaults), during major competitions from 2008 to 2015, is shown in Figure 1.

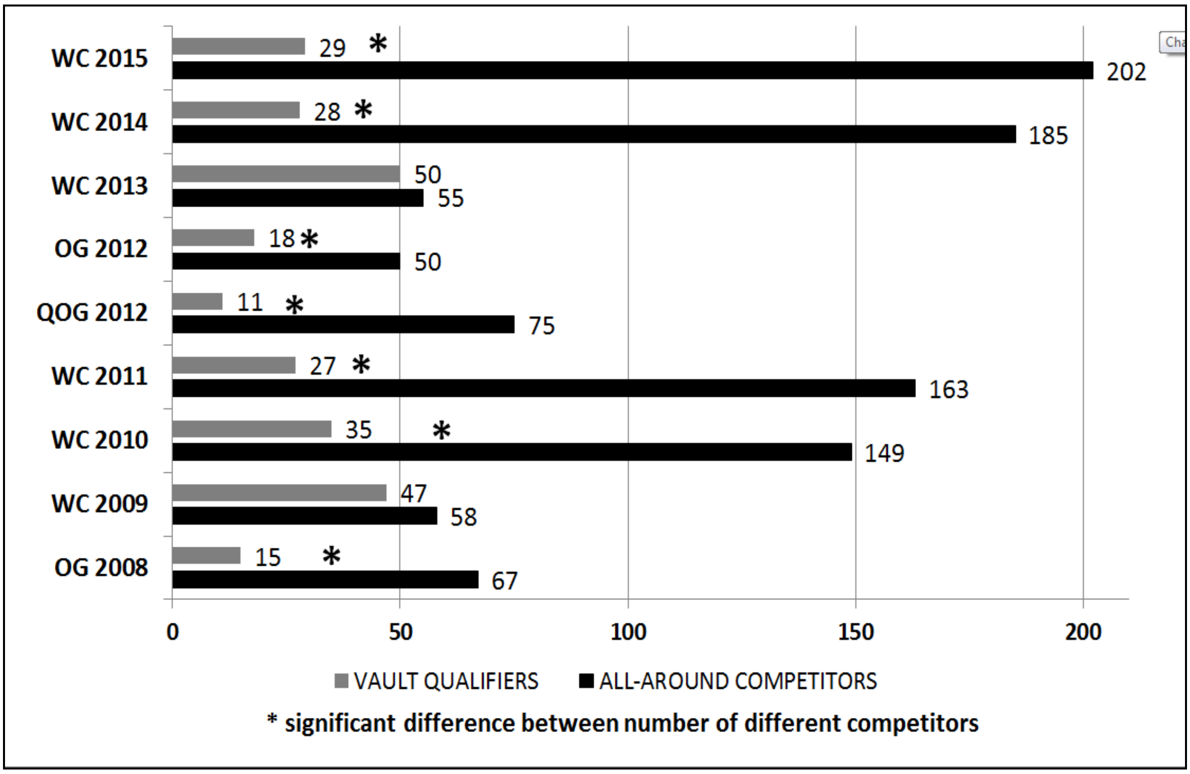

Figure 1. Number of All-Around women gymnasts and Vault Qualifiers in C-I competitions at different major competitions from 2008 to 2015.

Since a different number of competitors competed at the analysed competitions, the percentage of those who competed two vaults, compared to those who competed only one vault, is the best indicator of the portion of Vault Qualifiers within all competitors at C-I, in the analysed competitions.

Accordingly, the following was calculated: the highest percentage of gymnasts who competed two vaults was at the WC2009 (81.03%) and at the WC2013 (90.90%). In other competitions, significantly lower percentages of gymnasts who competed two vaults compared to those who competed only one vault, were determined: at the OG2008 – 22.38%, at the WC2010 – 23.48%, at the WC2011 – 16.56%, at the QOG2012 – 14.66%, at the OG2012 – 36.00%, at the WC2014 – 15.13% and at the WC 2015 – 14.36%.

Descriptive parameters (Mean Values ± Standard Deviations) of variables *DS*, *ES*, *FS* and *TS* respectively, achieved at C-I, and differences between gymnasts who competed All-Around and those who competed Vault Qualifications (determined at OG2008, WC2009, WC2010, WC2011, QOG2012, OG2012, WC2013, WC2014, WC2015), are presented in Figures 2-4.

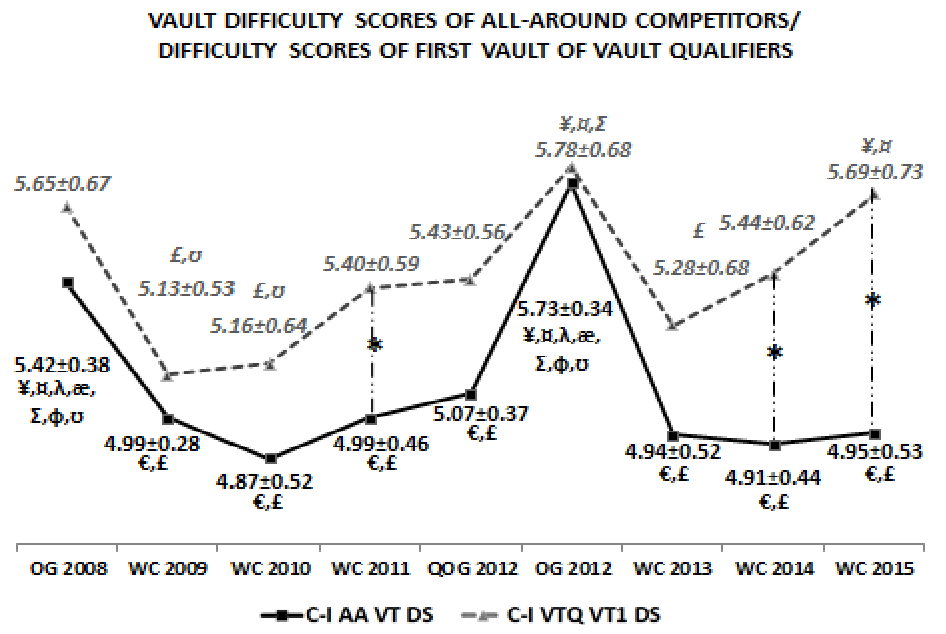

Figure 2. Difficulty scores on vault (all-around competitors vs first vault qualifiers).

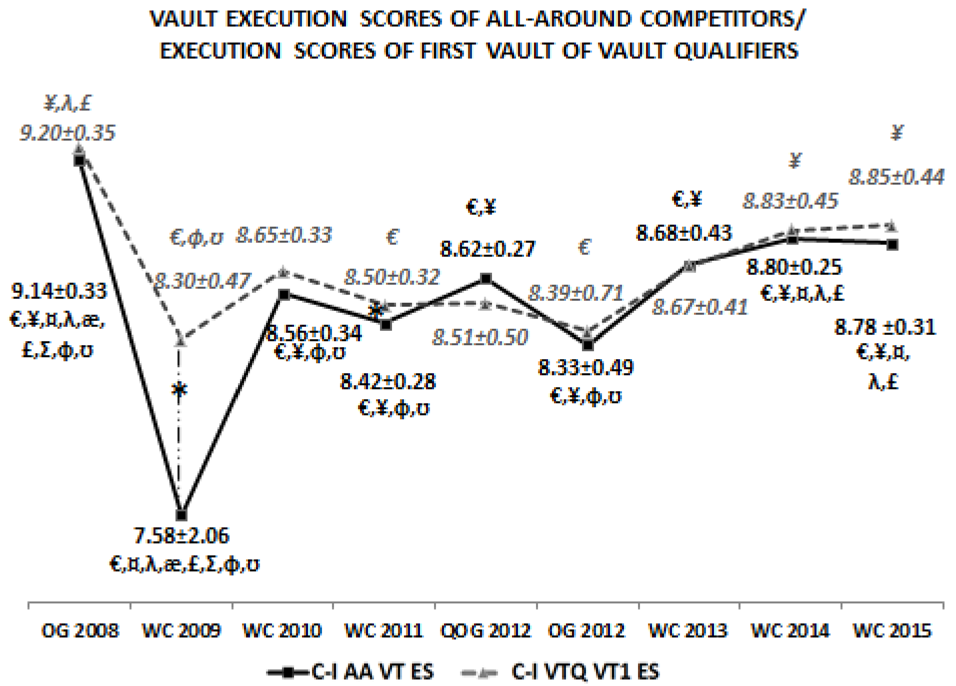

Figure 3. Execution scores on vault (all-around competitors vs first vault qualifiers).

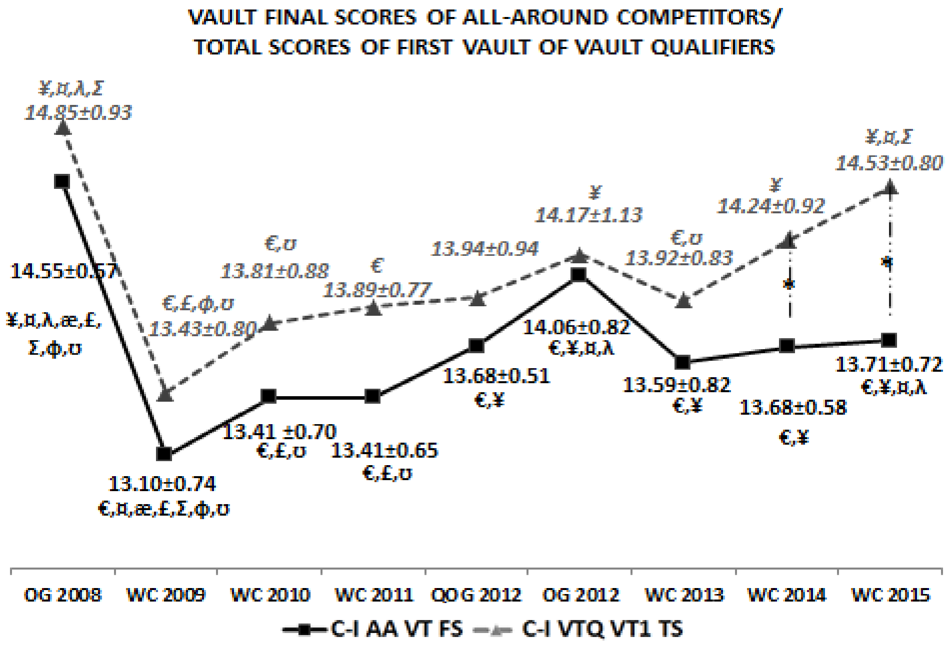

Figure 4. Final scores on vault (all-around competitors vs first vault qualifiers).

Figure 2-4. Data are presented as Mean±Standard Deviation. OG2008 – Olympic Games held in 2008, WC 2009/2010/2011/2013/2014/2015 – World Championships held in 2009/2010/2011/2013/2014/2015, QOG 2012 – Qualification Tournament for Olympic Games held in 2012, OG2012 – Olympic Games held in 2012, AA – All-Around Competitors, VTQ – Vault Qualifiers, € - significant difference from the scores determined at OG2008, ¥ - significant difference from the scores determined at WC2009, ¤ - significant difference from the scores determined at WC2010, λ - significant difference from the scores determined at WC2011, æ - significant difference from the scores determined at QOG2012, £ - significant difference from the scores determined at OG2012, Σ - significant difference from the scores determined at WC2013, ϕ - significant difference from the scores determined at WC2014, ʊ - significant difference from the scores determined at WC2015, *- significant differences between only vault of All-Around competitors and first vault of Vault Qualifiers. Significance of differences was examined by using Bonferroni post hoc correction of main effects and interaction effects of 2*9 factorial ANOVA.

For the *DS* of the 1st vault of All-Around competitors and the 1st vault of the Vault Qualifiers, main effect of *Competition* was found to be significant ($F_{8,1246}$ = 14.923; p < .001; η^2 = .087), together with main effect of *Competitor Type* ($F_{1,1246}$ = 77.754; p < .001; η^2 = .059) and interaction *Competition*Competitor Type* ($F_{8,1246}$ = 3.738; p < 0.01; η^2 = .023). Similarly, for the *ES* of the 1st vault of All-Around competitors and the 1st vault of Vault Qualifiers, main effect of *Competition* was found to be significant ($F_{8,1250}$ = 29.618; p < .001; η^2 = .159), as well as main effect of *Competitor Type* ($F_{1,1250}$ = 6.482; p = .011; η^2 = .005) and interaction *Competition*Competitor Type* ($F_{8,1250}$ = 4.235; p < 0.001; η^2 = .026). For the *FS* of the 1st vault of All-Around competitors and the *TS* of the 1st vault of Vault Qualifiers, main effect of *Competition* ($F_{8,1246}$ = 22.812; p < .001; η^2 = .128) and of *Competitor Type* ($F_{1,1246}$ = 50.534; p < .001; η^2 = .039) was found to be significant. For the *FS* of the 1st vault of All-Around competitors and the *TS* of the 1st vault of Vault Qualifiers interaction *Competition*Competitor Type* was not significant ($F_{8,1246}$ = 1.651; p = .106; η^2 = .010).

Descriptive parameters (Mean Values ± Standard Deviations) of variables *DS*, *ES* and *FS* of the only vault of All-Around competitors together with *DS*, *ES*, and *TS* of the 2nd vault and the *FS* of Vault Qualifiers, achieved at C-I, and differences between those variables (determined at OG2008, WC2009, WC2010, WC2011, QOG2012, OG2012, WC2013, WC2014, WC2015), are presented in Figures 4-7.

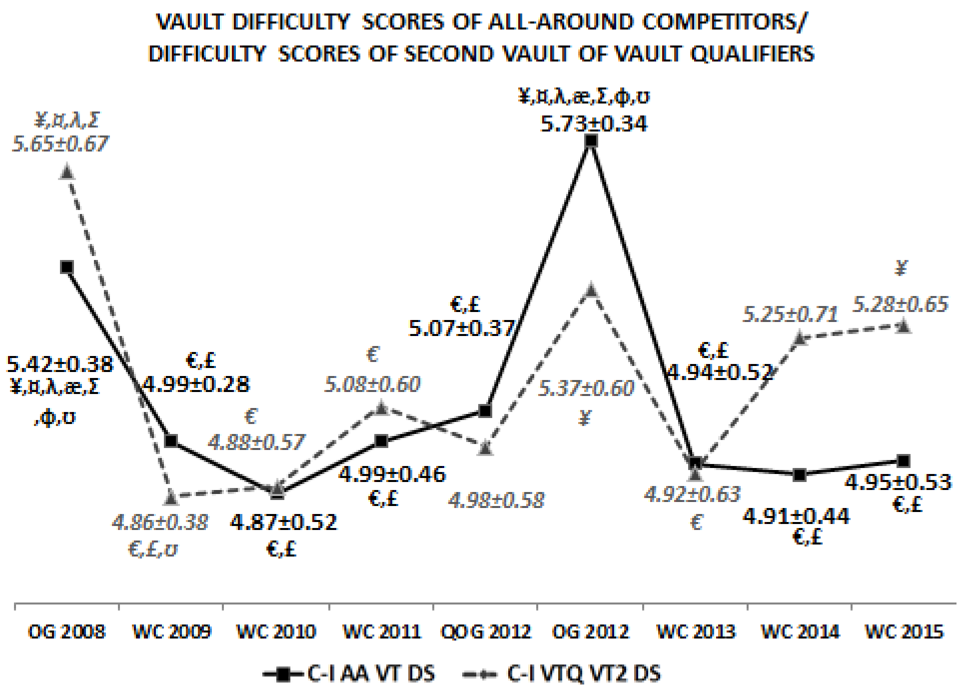

Figure 5. Difficulty scores on vault (all-around competitors vs second vault qualifiers).

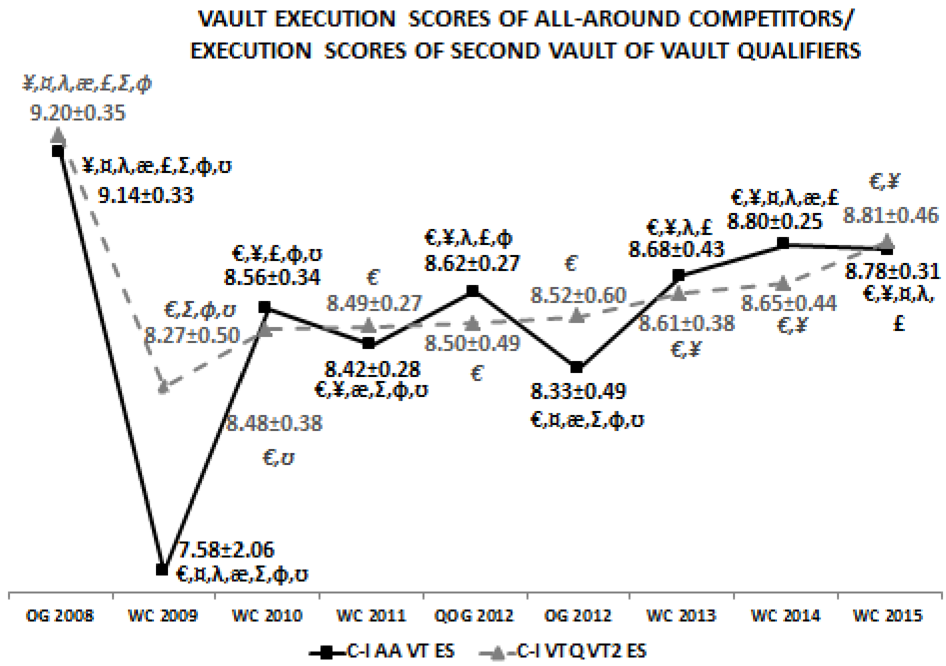

Figure 6. Execution scores on vault (all-around competitors vs second vault qualifiers).

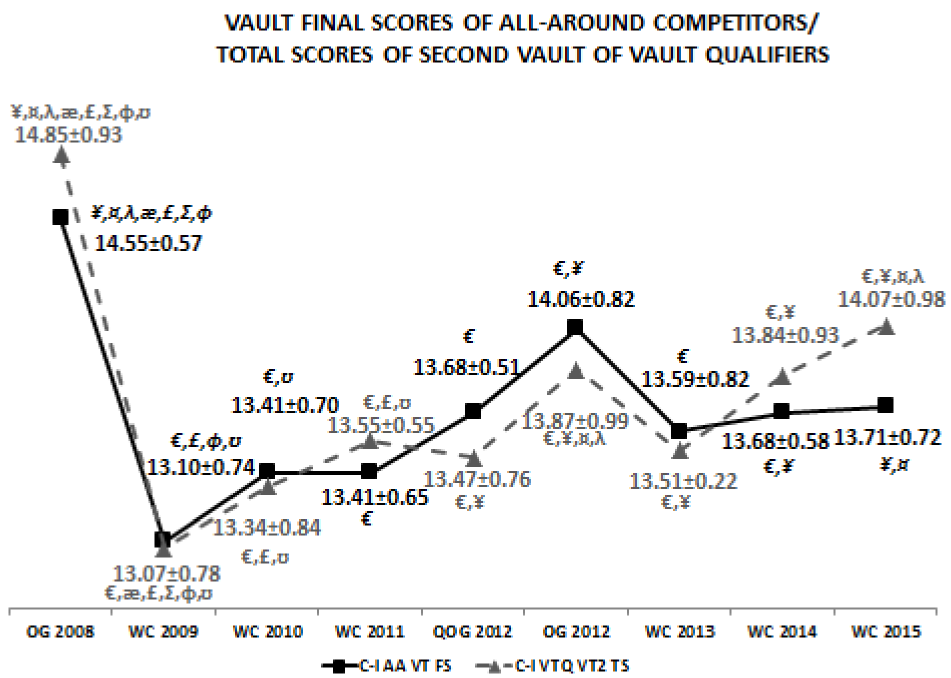

Figure 7. Final scores on vault (all-around competitors vs second vault qualifiers).

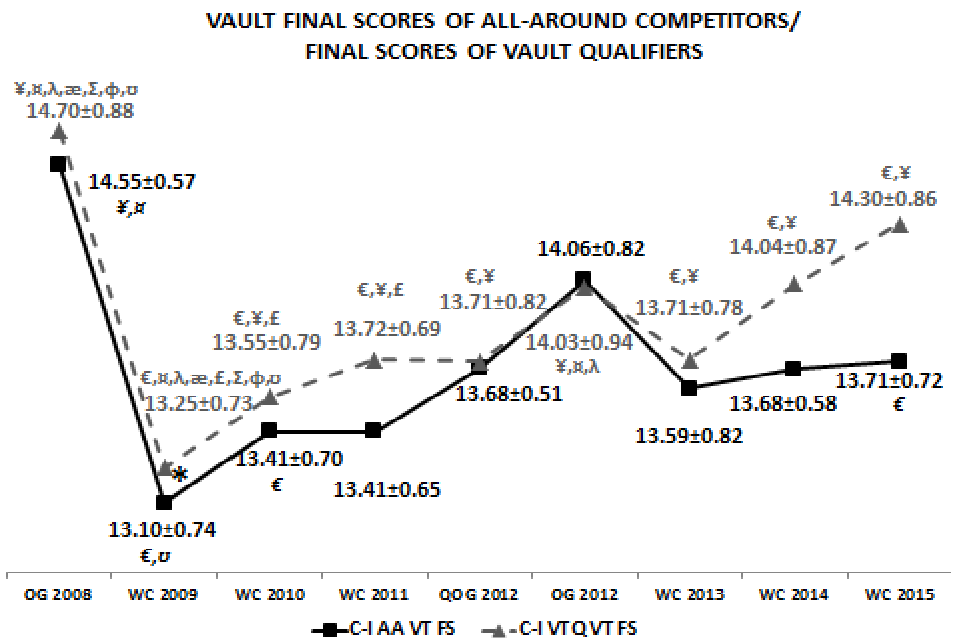

Figure 8. Final scores on vault (all-around competitors vs vault qualifiers).

Figures 5-8. Data are presented as Mean±Standard Deviation. OG2008 – Olympic Games held in 2008, WC 2009/2010/2011/2013/2014/2015 – World Championships held in 2009/2010/2011/2013/2014/2015, QOG 2012 – Qualification Tournament for Olympic Games held in 2012, OG2012 – Olympic Games held in 2012, AA – All-Around Competitors, VTQ – Vault Qualifiers, € - significant difference from the scores determined at OG2008, ¥ - significant difference from the scores determined at WC2009, ¤ - significant difference from the scores determined at WC2010, λ - significant difference from the scores determined at WC2011, æ - significant difference from the scores determined at QOG2012, £ - significant difference from the scores determined at OG2012, Σ - significant difference from the scores determined at WC2013, ϕ - significant difference from the scores determined at WC2014, ʋ - significant difference from the scores determined at WC2015, *- significant differences between only vault of All-Around competitors and second vault/average score of Vault Qualifiers. Significance of differences was examined by using Bonferroni post hoc correction of main effects and interaction effects of 2*9 factorial ANOVA.

Regarding the 1st vault of All-Around competitors and the 2nd vault of Vault Qualifiers, main effect of *Competition* was found to be significant for the *DS* ($F_{8,1246}$ = 16.576; p < .001; η^2 = .096), *ES* ($F_{8,1246}$ = 43.658; p < .001; η^2 = .219) and the *FS/TS2* ($F_{8,1246}$ = 27.513; p < .001; η^2 = .150). Main effect of *Competitor Type* was not found to be significant for the *DS* ($F_{1,1246}$ = 1.359; p = .244; η^2 = .001), *ES* ($F_{1,1246}$ = .153; p = .695; η^2 = .000) and the *FS/TS2* ($F_{1,1246}$ = .642; p = .423; η^2 = .001). Interaction *Competition*Competitor Type* was significant for the *DS* ($F_{8,1246}$ = 4.135; p<0.01; η^2 = .026), *ES* ($F_{8,1246}$ = 2.322; p = .018; η^2 = .015), but not for the *FS/TS2* ($F_{8,1246}$ = 1.503; p = .152; η^2 = .010). By analysing the *FS* of the 1st vault of All-Around competitors and the *FS* of Vault Qualifiers, main effect of *Competition* was found to be significant ($F_{8,1250}$ = 20.142; p < .001; η^2 = .114) together with main effect of *Competitor Type* ($F_{1,1250}$ = 14.486; p < .001; η^2 = .011) and interaction *Competition*Competitor Type* ($F_{8,1250}$ = 2.334; p = .017; η^2 = .015).

DISCUSSION

Regardless of the fact that the vault is the most studied apparatus and also the best understood one (Prassas, Kwon, & Sands, 2006), the number of gymnasts who compete two vaults is probably lower than the number of competitors who compete on other apparatuses in order to qualify for Apparatus Finals. However, this conclusion requires further scientific research.

Determined percentages of the gymnasts who competed Vault Qualifications (and performed two vaults), compared to those who competed All-Around (and performed only one vault), according to the authors, are the result of: 1) the rules and different formats of the analysed competitions; 2) specific biomotor characteristics of competitors that are needed in order to perform structurally more complex vaults; vaults of higher *DV*; 3) competitors' and national (expert) teams' tactics.

Different rules and systems of qualification for major events, together with different subjective factors of gymnasts, resulted in a different number/percentage of Vault Qualifiers at C-I competition. Competitions with the highest percentage of Vault Qualifiers (WC2009 and WC2013), by their format, were Individual All-Around Finals (C-II competition) and Individual Event Finals (C-III competition). In general, these are competitions where the results have no impact on competitors' future participation at the following Olympic Games (probably the main goal of most gymnasts and their national teams). At such competitions, gymnasts exclusively compete for their own results and test their knowledge/skills/chances for the upcoming Olympic cycle. A large number of Vault Qualifiers, in the aforementioned competitions, is most likely the result of the fact that the 2nd vault score (according to the CoP's) does not jeopardize their All-Around Results, but provides them information on their position within the group. In accordance with the previous results, expert teams should (and probably they did) plan and program further training of their competitors. By identifying that a competitor does not have a real chance of entering the Vault Finals in the following major competitions, they probably did not spend too much time on their training sessions in improving both vaults. This conclusion primarily relates to the periods before major competitions in which competitors competed only All-Around.

In contrast to the abovementioned competitions (C-II and C-III competitions), in Team Finals (C-IV competition), national (expert) teams (and accordingly gymnast) do not have space for any calculation and/or experimentation with uncertain performances on any apparatus of All-Around (including the vault). Confirmation for these conclusions can be perceived from the results of all other major competitions (from 2008 to 2015) which, in addition to C-II and C-III competition, were also the Team Finals (C-IV competition). As shown in Figure 1, in those competitions, less than

20% gymnasts competed in Vault Qualification.

Generally speaking, a review of results in Figure 1 and 2 shows that the trend in the results of AA VTDS, VTQ VT1DS, AA VTFS and VTQ VT1TS were very similar, while the trend in AA VTES and VTQ VT1ES results were slightly different (Figure 3). At the same time, it is important to point out that the results of *VTQ VT1DS* and *VTQ VT1TS*, in all the analysed competitions, were numerically higher and in some competitions even significantly higher in comparison to the results of *AA VTDS* and *AA VTFS*. Since the scores of the 1st vault of Vault Qualifiers count for Team Result and Individual All-Around Result (FIG, 2009, 2013), it is not surprising that for the 1st vault they chose vaults whose *DVs* are numerically higher (and sometimes significantly higher) from those performed by All-Around Competitors.

The size of the determined differences between All-Around Competitors and Vault Qualifiers become additionally important if we take into account two facts: 1) possible weak discrimination of competitors in the *DS*; 2) non-differentiation among Vault Qualifiers and All-Around competitors in the *ES*.

Namely, if we assume that there is a similarity between the MAG CoP and the WAG CoP, and if we review the results of some previous studies on the MAG scores (according to which in the Vault Qualifications there is not enough discrimination between competitors in the *DS*; Čuk & Atiković, 2009; Čuk & Forbes, 2010; Bučar Pajek, Forbes, Pajek, & Leskošek, 2011; Bučar, Čuk, Pajek, Karácsony, & Leskošek, 2012; Bučar Pajek, Čuk, Pajek, Kovač, & Leskošek, 2013), then we can conclude that the determined differences are large; independently from the fact that they numerically range only from 0.23 (OG2008) to 0.74 (WC2015). The fact that significant differences were not determined in the *ES* values between Vault Qualifiers and All-Around Competitors suggests that All-Around Competitors perform their only and less demanding vault technically and aesthetically as well as the Vault Qualifiers.

The results of this study showed that the *DS*, on average, makes around 36.85% of the *FS/TS1/TS2* (percentage range of the *DS* in the *FS/TS1/TS2* is from 36.16% (WC2014) up to 40.74 (OG2012)) while the *ES*, on average, makes approximately 63.29% of the *FS/TS1/TS2* (the *ES* percentage in the *FS/TS1/TS2* range from 59.61% (OG2012) up to 64.07% (WC2014)). The obtained results don't confirm conclusions from previous studies which state that the *DS* generally determines the *VTFS/VTTS1/VTTS2* (Čuk & Atiković, 2009; Čuk & Forbes, 2010; Bučar Pajek, Forbes, Pajek, & Leskošek, 2011; Bučar, Čuk, Pajek, Karácsony, & Leskošek, 2012; Bučar Pajek, Čuk, Pajek, Kovač, & Leskošek, 2013; Massida & Calo, 2012). According to those results, the *ES* is the main score in determining *FS/TS*.

The present study aims at underlining the fact that the vault *DS* is the parameter that affects the difference between *VT1TS* of Vault Qualifiers and *VTFS* of All-Around Competitors. However, according to research Čuk, Fink & Leskošek (2012), there is a possibility of neglecting the above-mentioned fact. Namely, the authors show that the proportion between the *DS* and the *ES*, according to different formulas, can range from 17% to 67% .With the different proportions in the *FS* calculations, the number of changes in the rankings is high: 81% in C-I and C-II 61% and 35% and C-III.

Trend in the *DS* results in C-I competitions, in both groups of competitors, showed a sinusoidal trend of results between the two analysed Olympic Games. After the OG2008 and the OG2012 (where generally the highest values of all the analysed variables were determined) there has been some numerical decrease in *DV's* of the performed vaults. However, this statement is not entirely accurate due to the changes that occurred in the CoP at the beginning of each new Olympic cycle and duration of the career of most women All-Around Competitors.

Establishing high frequencies of certain vaults at major competitions often results in a reduction of the *DV* in one of the following CoP. This might lead to weak differentiation between competitors, such as in Men's Artistic Gymnastics (Čuk & Atiković, 2009; Čuk & Forbes, 2010; Bučar Pajek, Forbes, Pajek, & Leskošek, 2011; Bučar, Čuk, Pajek, Karácsony, & Leskošek, 2012; Bučar Pajek, Čuk, Pajek, Kovač, & Leskošek, 2013; Massida & Calo, 2012). The same situation occurred in every CoP after 2005, to some vaults that had high or the highest *DV*. If the aforementioned is related to some extent to findings in this study, we may claim that it is likely that a large number of competitors performed precisely those vaults whose *DV* (after certain OG) has been reduced. Also, it is possible that there was no decline in the difficulty of the performed vaults, i.e., determined numerical reduction is the result of the CoP *DV* decrease. Yet, further research on the issue should be done in the future.

Participation in the Olympic Games is usually the main goal in every gymnast's career. After participating at the OG a large number of competitors, in particular All-Around Competitors, very often end their careers. This was probably the case with the OG2008 and the OG2012 after which 'new' competitors entered the game. If it is known that female gymnasts' biological maturation comes later compared to the average population (Malina, 1994; Malina, 1998; Bass et al., 2000; Courtei, Jaffre, Obert, & Benhamou, 2001; Baxter-Jones, Thompson, & Malina, 2002; Bass, Daly, & Cane, 2002; Caine, Bass, & Daly, 2003; Baxter-Jones, Maffulli, & Mirwald, 2003; Daly, Caine, Bass, Pieter, & Broekhoff, 2005; Erlandson, Sherar, Mirwald, Maffulli, & Baxter-Jones, 2008), and, accordingly, their biological maturity characterized by the stability of the motor programs (Arkaiev & Suchilin, 2009), it is possible that a number of 'new' female seniors was not biologically mature. Younger gymnasts, particularly those who have not yet gone through puberty, tend to be lighter and smaller (Claessens et al., 1991, 2006), more pliable and flexible, have better strength-to-weight ratio than older gymnasts. When a female gymnast hits puberty, growth spurts and weight gain may affect her center of gravity, causing mental and physical stress as she must adjust, and in some cases relearn, her moves to compensate (https://en.wikipedia.org/wiki/Age_requirements_in_gymnastics). And while such characteristics are desirable for other apparatuses, the authors believe that they do not contribute to better performance of the vault. Furthermore, the opinion of the author relies on the Arkaev and Suchilin (2009) statement that somewhat higher and heavier female gymnasts will probably perform vaults better. How many competitors with such anthropometric characteristics there were, and how are these important for the better performance of the vault remains to be examined in future research.

The importance of morphological characteristics in vault performance in men's artistic gymnasts was found in the study conducted by Možnik et al. (2013). The authors found that the best ranked gymnasts on the vault have lower body height and weight compared to the best gymnasts on parallel bars and high bar.

Accordingly, due to anthropometric characteristics (Erceg, Delaš Kalinski, & Milić, 2014), and, according to practical point of view, due to different factors of limitation in motor learning processes (Schmidt & Wrisberg, 2008), those gymnasts were likely not able to perform, in their first year of competition in senior category, vaults that had *DV's* similar to those determined in the previous Olympic Games.

However, through their biological maturation and automatization of their performances (Schmidt & Wrisberg, 2008), by the end of the Olympic cycle, they achieved equal *DV's* to those determined at the previous Olympic Games. Achieving the same and/or even higher results than the ones from the previous Olympic Games, with reduced *DV's* of vaults compared to the *DV's* of the same vaults at the previous

Olympic Games, simply confirms the thesis about progress in the quality and complexity of vaults in WAG. Taking into account the trend of the results after the OG2012, especially the ones determined at the WC2015, it is to assume that at the OG2016 the results of All-Around Competitors would be similar to the ones from the OG2012. For the Vault Qualifiers at the OG2016, we can expect numerically slightly higher results from the ones determined at the OG2012.

Trend of the *ES* results also shows that Vault Qualifiers, in almost all the analysed competitions, had numerically higher values than All-Around Competitors. In contrast to the sinusoidal trend of the *DS* results, we can say that the results of the *ES* showed significant decrease only after the OG2008. It was probably due to the introduction of the rules of landing within the 'CORIDOR'. Numerically higher values of All-Around Competitors, compared to Vault Qualifiers, in the *ES* determined at the QOG2012, emphasize the quality of the performance, i.e., readiness of All-Around Competitors for this competition: their "last train for Olympics 2012". After the OG2012 and after certain changes in the rules of landing, steady progress of the *ES*, both for All-Around Competitor and Vault Qualifiers was determined. Since the introduction of the 'new method of judging' (FIG, 2006) had the intention of improving competitors performance, based on these results, we may conclude that the competition on vault definitely does go in that direction. It is obvious that for all competitors the performance of vaults becomes '... more important and making vault seem more like a full routine instead of two separate skills in which if you mess up on those, you can make up for it on the other' (https://betweentheolympics.wordpress.com/2012/04/02/vault-in-the-proposed-2013-2016-code-of-points/).

As mentioned above, it has been determined that the development of the *FS/TS1* is similar to the trend of the *DS* results: after the OG2008 and the OG2012 value of the *FS/TS1* decreased, while the values of the *FS/TS1* between those competitions increased. Slightly different from the trend in the *DS*, significant difference between All-Around Competitors and Vault Qualifiers in the *FS/TS1* was determined only in two competitions (WC2014 and WC2015). Since the *FS/TS1* is a composite of the *DS* and the *ES*, the obtained results confirm previously established progress in performance of All-Around Competitors.

Review of results in Figures 5-8 (values of different variables of the only vault of All-Around Competitors and of the 2nd jump of Vault Qualifiers) generally present similarity between those vaults. Similarity is also confirmed by not determining significant differences in any variables between those two vaults. The result should be viewed through the abovementioned rules for competing in Vault Qualifications: according to the CoP 2009 it was necessary to perform two vaults that are different in the 1st and the 2nd phase of the flight; according to the CoP 2013 it was necessary to perform two vaults in different groups and with different second flight phase. This leads to the conclusion that female Vault Qualifiers generally cannot perform equally good vaults that are structurally different. The authors believe that there are several reasons for this: 1) shorter time that gymnasts dedicate to vault training compared to the time invested in training of other apparatuses, (Čuk & Karácsony, 2004); 2) complexity of those motor skills (vaults); 3) anthropometric characteristics of gymnasts (Erceg, Delaš Kalinski, & Milić, 2014; Delaš Kalinski, 2015).

Moreover, the authors claim that the contained results raise the question (for further research) of the real equality of the *DV's* of vaults that classified in different vault groups in the WAG CoP.

CONCLUSION

The percentage of female competitors, who participated in Vault Qualifications with the aim to qualify for Vault Finals at the analysed competitions (from 2008 to

2015), depended on the format of the competition. At the competitions which were not Team Finals Competition (C-IV), the percentage of Vault Qualifiers was 81.03% (WC2009) and 90.90% (WC2013). At the other analysed competitions, only 20% of competitors were Vault Qualifiers.

Although all the analysed competitions were of the highest level, we conclude that some factors from anthropological status, motor learning process and competitors' tactics caused numerical differences and in some competitions even significant differences (in the *DS* between the only vault of All-Around Competitors and the 1st vault of Vault Qualifiers). Consequently, in some competitions the differences were determined between *VTFS* of All-Around Competitors and *VT1TS* of Vault Qualifiers. Significant differences were not determined between variables of the 2nd vault of Vault Qualifiers and variables of the only vault of All-Around Competitors.

Based on the determined results, we claim that the structural complexity of two different vaults (regardless of the fact that those are the only two skills, which is significantly less when compared to the number of elements performed during an exercise on other apparatuses) is such that most female gymnasts cannot perform them equally well.

Regardless of the *DV's* of vaults that they performed, significant differences between All-Around Competitors and Vault Qualifiers were not determined in the *ES*. This leads to the conclusion that both female competitor groups performed their vaults equal in technical and aesthetical sense.

Since the vault is an apparatus that constantly develops in the direction of more and more difficult vaults, the results of this study should be taken into account when planning and programming training sessions for competitors who aspire toward the Vault Finals.

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Corresponding author:

Sunčica Delaš Kalinski, PhD
University of Split
Faculty of Kinesiology
6, Teslina
21000 Split
Croatia
Phone: +385 21 302 440;+385 91 502 97 51
e-mail: suncica@kifst.hr

ACCURACY OF PREDICTION OF MAXIMUM RESISTANCE AT INCREASED HOLDING TIMES BASED ON A THREE SECONDS MAXIMUM STATIC STRENGTH TEST OF THE THREE MAIN STRENGTH ELEMENTS ON RINGS

Christoph Schärer, Klaus Hübner

Swiss Federal Institute of Sports Magglingen, Switzerland

Original article

Abstract

On rings in men's artistic gymnastics, a high degree of relative maximum strength is crucial to present up to seven strength elements in the required quality in the routine. To increase this specific strength and strength endurance the coaches often prolong the holding times of those elements by using the devices counterweight and additional weight in training. The purpose of this study was to investigate the predictability of the maximum resistance (MR) (minimal counterweight/maximum additional weight) at five and seven seconds holding times based on the MR at three seconds of the elements Iron Cross (C), Support Scale (SS) and Swallow (S) and to provide coaches with a reliable conversion table that predicts the individual training weights at different holding times. Ten male gymnasts of the Swiss National Team performed a specific static MR-Test (three, five and seven seconds holding time) of the elements C, SS and S. The results showed a significant decrease in MR as holding time increased (t-Test: $p < 0.001$). The standard error of estimate (SEE) and explained variance (R^2) revealed that the prediction of MR at five seconds (SEE 0.52 kg to 1.03 kg, R^2 0.92 to 1.00) was more accurate than at seven seconds holding time (SEE 0.95 kg to 2.08 kg, R^2 0.88 to 0.98). Based on the linear regression equations, a useful conversion table was established that predicts the MR at five and seven seconds holding time based on the three seconds MR at each of the tested elements.

Keywords: *Artistic Gymnastics, rings, strength, swallow, cross, support scale.*

INTRODUCTION

The Code of Points (CoP) of the International Gymnastics Federation (FIG) (FIG, 2013) regulates the scoring of elements and amongst others, prescribes the composition of the routines for each of the six disciplines in men's artistic gymnastics (MAG). On rings, a routine can include a maximum of seven strength elements, which have to be held in a perfect hold position, prescribed in the CoP, for at least two seconds. All angular deviations and reduction of holding time will result in deductions or non-recognition by the jury (FIG, 2013). In order to present a routine in the prescribed quality, a high level of relative maximum strength in the different hold positions is required. To increase this specific strength, it is essential that the strengthening exercises are similar, if not identical, to the holding positions of the ring elements, and that exercise intensity is optimal.

Traditionally, the hold elements are trained with help of the coaches who guide athletes' motion or partially support their body weight. The disadvantage of spotting is that the intensity of the strength training cannot be modulated optimally. On the other hand, common strengthening exercises with barbells or dumbbells, while allowing intensity to be controlled precisely, do not elicit muscle activation patterns similar to those during elements on rings (Bernasconi, Tordi, Parratte & Rouillon, 2009). Furthermore only a few preconditioning exercises seem to be strongly correlated to the holding elements on rings (Hübner & Schärer, 2015).

As specificity and progression are both fundamental principles of strength training and as the development of the specific relative maximum strength is one of the most important goals in training for the rings, there is a need for training devices that meet both demands – specificity and control of intensity. Moreover, considering the fact that coaches need to continuously adapt training stimuli to maximize progress of the athletes, they are in need of easily applicable measurement tools to regularly assess the specific maximum strength. Previously published studies have focused on the application of a specific force measurement device (Starischka & Tschiene, 1977), force plates (Gorosito, 2013; Dunlavy et al., 2007) or electromyography (Bernasconi et al., 2009; Bernasconi, Tordi, Parratte, Rouillon & Monnier, 2006). Tests using those devices must be conducted by experts and the testing procedures developed in these studies only assess the athletes' current condition. Thus, coaches cannot deduce the essential stimulus intensity needed for training.

The training devices "Counterweight" (CW) (figure 1) and "Additional Weight" (AW) (figure 2) present simple and practical means of training and testing maximum resistance (MR) in all hold positions on rings. The CW diminishes the gymnast's body weight by a pulley and activates similar muscle patterns to the ones activated without device (Bernasconi et al., 2009). The AW increases the resistance during the hold element by adding weight to a belt. Thus, it is possible that coaches can determine athletes' individual MR represented by either the minimal counterweight or maximal additional weight in each holding position during regular training sessions. As a result, the optimal specific training intensity can be deduced, which according to Mironov & Schinkar (1995) is an effective way to improve the individual level of relative maximal strength. In addition, with these devices, athletes have direct feedback regarding their training progress, which is important for their future motivation in strength training.

Coaches are constantly on the lookout for new, more effective strength training methods, which may allow athletes to include more difficult strength elements with a higher quality in their routines on the rings. A limiting factor for integrating new skills into a routine may be the specific maximal strength endurance in each holding position. Hence coaches often increase the holding times of the hold elements during the training sessions to five or even seven seconds in order to possess a higher level of MR than required during their routine. This is according to Arkaev and Suchilin (2004) crucial for presenting a routine in high quality. Until now, gymnasts needed several attempts to find the ideal counterweight or additional weight in order to hold the elements for five or seven seconds during training. To facilitate the determination of the training weights for the different holding times for the athletes and coaches, a conversion table (based on the MR at three seconds) would be of interest. In this manner, the exhaustive estimation of MR at longer holding times doesn't have to be conducted, and the risk of severe shoulder injuries due to excessive resistance can be minimized.

The aim of this study was to determine the predictability of maximum resistance (MR), in terms of counterweight or additional weight, at different holding times (five and seven seconds) based on the MR at three seconds of the hold elements Iron Cross (C), Support Scale (SS) and Swallow

(S) on rings, and to provide coaches with a reliable conversion table (CT) for predicting the training weight needed to hold an element for five and seven seconds based on individual MR for a three seconds holding time. Research question is what is the accuracy of prediction of maximum resistance at five and seven seconds holding times based on a three seconds static maximum strength test of the elements Iron Cross, Support Scale and Swallow on rings using the devices counterweight or additional weight? We hypothesized that accuracy of prediction of maximum resistance decreases with increasing holding times at the elements C, SS and S.

METHODS

To estimate MR in the hold positions of C, SS and S, two devices were used: the CW and the AW (Figures 1-6). For athletes who have not mastered the hold elements under original conditions, CW was used, whereas those who were able to execute the elements performed them either without any weight or with AW. The MR will be indicated as a negative value if CW was used and as positive value if the holding element was performed with AW.

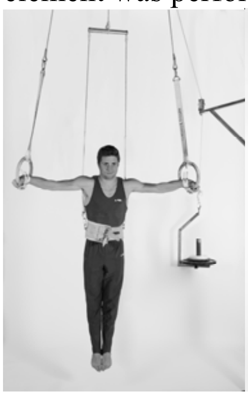
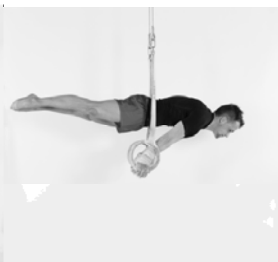



Figure 1. CW iron cross.
Figure 2. AW iron cross.

Figures 3. CW Support scale.
Figures 4. AW Support scale.


Figures 5. CW Swallow.
Figures 6. AW Swallow.

Ten top-level gymnasts from the Men’s Artistic Gymnastics Swiss National Team (Age: 21.5 ± 2.5 years; Weight: 65.0 ± 5.0 kg; Height: 168.6 ± 4.5 cm) volunteered to participate in this study. All gymnasts invest more than 25 hours per week in a professional gymnastics training. Athletes were informed in advance about the test procedures, which were accepted by an ethics committee.

The tests were conducted on two separate days. On the first day, athletes performed the C; on the second day, they performed the SS and S. After an individual 20-minute warm-up, all gymnasts executed the strength elements for three, five and seven seconds in three randomized trials. Athletes had maximum three attempts per element and holding time in order to execute the element for the required time with maximal resistance. Between attempts, athletes had a twenty minutes break.

After adjusting the weight, athletes had to lower themselves into the correct position out of the support position and hold the element for the required time. All trials were captured by a video camera (Sony HDR-CX730E, Sony, Japan) positioned in front (for C) or on the side (for SS and S). Angular deviations and the time the elements were held were analyzed with Kinovea Software 0.8.15 (www.kinovea.org). Attempts were only valid if the angular deviations were within the requirements of the CoP (< 45°) (FIG, 2013). Time measurement started when a complete stop position was reached (maintaining the holding position during at least two subsequent video frames) and stopped by the time the athlete aborted the hold position or if the hold element would no longer have been recognized according the rules of the COP due to angular deviations of more than 45° (figure 7). Joint angles were estimated by marking the relevant joint centers (wrist, shoulder, hips or ankle) with the angular measurement tool of the software. This two-dimensional joint-angle video-analysis method showed high intratester reliability (Stensrud, Myklebust, Kristianslund, Bahr, Krosshaug, 2010) and concurrent validity (Norris & Olson, 2011) in medical test settings.

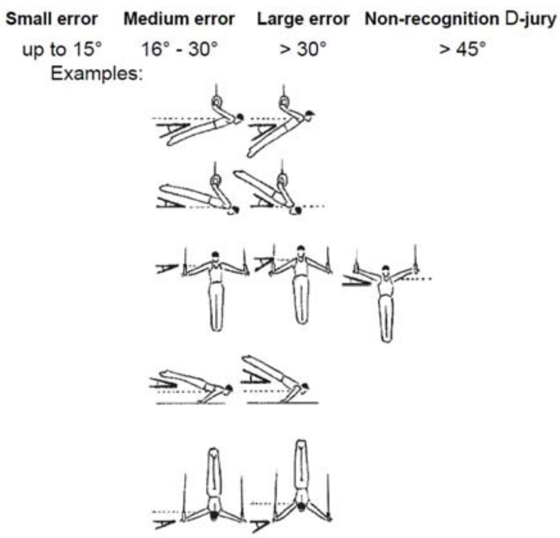


Figure 7. FIG (2013) error definition.

Mean value (M) and standard deviation (SD) of all variables were calculated. A simple linear regression equation (y = ax + b), the variance explained (R^2) (multiple regression analysis) and the standard error of estimate (SEE) were determined to describe the relationship between the MR and the different holding times for each element (C, SS, S). A t-Test was used to describe the differences between the MR at the different holding times. Using the obtained simple linear regression equations, a conversion table was calculated for the training weights at five and seven seconds holding time based on the weights at three seconds. The level of significance was set to $p < 0.05$. All statistics were performed using SPSS 22 software (SPSS, Inc., Chicago, IL).

RESULTS

Due to elbow pain resulting from a previous trauma one athlete was unable to execute the tests of C and S and felt pain holding the element SS. For this reason his results were excluded from the calculations. None of the other athletes were previously injured nor did they experience pain during the tests.

Descriptive data and achieved performances of MR at the elements C, SS and S and the effective holding times are shown in table 1.

All athletes showed the C without counterweight for the three seconds holding time. For the five and seven seconds holding times, two and four athletes, respectively, needed a counterweight in order to hold the position for the required time. The SS was hold by two athletes with additional weight. For the S, counterweights were required with the exception of one athlete for the three seconds holding time.

There were mostly minor differences between the prescribed and mean measured holding times except at the seven seconds holding time of the element S.

Mean values of the MR and the effective holding times as well as regressions and simple equation formulas for the C, SS and S are shown in Figures 8 to 10.

Table 1

Descriptive data and achieved performances of MR and the effective holding times

Athlete		1	2	3	4	5	6	7	8	9
Iron Cross	MR 3s (kg)	0.00	3.00	6.00	4.00	8.00	1.00	7.00	0.00	1.00
	MR 5s (kg)	-5.00	2.00	5.00	2.00	6.00	0.00	5.00	-3.75	0.00
	MR 7s (kg)	-10.00	0.00	2.00	0.00	5.00	-2.50	2.00	-7.50	-7.50
	Time 3s	3.12	2.32	2.48	3.80	3.92	3.00	3.52	3.52	2.96
	Time 5s	5.92	4.76	4.56	5.92	5.56	5.56	4.96	4.24	4.88
	Time 7s	8.20	6.68	6.52	7.92	6.88	7.64	7.44	7.72	7.08
Support Scale	MR 3s (kg)	-10.00	-8.75	-7.50	0.00	1.00	-10.00	1.00	-17.50	-5.00
	MR 5s (kg)	-13.75	-12.50	-10.00	-2.50	0.00	-15.00	0.00	-20.00	-6.25
	MR 7s (kg)	-15.00	-15.00	-12.50	-3.75	-3.75	-17.50	-2.50	-22.50	-7.50
	Time 3s	3.64	3.60	3.08	3.56	2.92	2.80	3.56	3.08	2.24
	Time 5s	4.52	5.44	5.40	5.64	4.60	5.12	5.60	4.80	4.28
	Time 7s	7.04	7.16	10.00	8.16	5.92	8.11	8.24	9.08	6.76
Swallow	MR 3s (kg)	-17.50	-7.50	-11.25	-7.50	-7.50	-17.50	0.00	-25.00	-12.50
	MR 5s (kg)	-20.00	-10.00	-12.50	-10.00	-8.75	-18.75	-1.25	-28.75	-15.00
	MR 7s (kg)	-22.50	-15.00	-13.75	-11.25	-10.00	-20.00	-2.50	-30.00	-20.00
	Time 3s	3.28	3.68	1.48	4.25	3.72	4.20	3.12	3.92	3.40
	Time 5s	4.64	5.48	5.56	5.72	4.88	5.92	4.00	7.44	4.92
	Time 7s	10.08	9.12	8.60	7.44	6.88	6.24	7.28	8.68	8.36

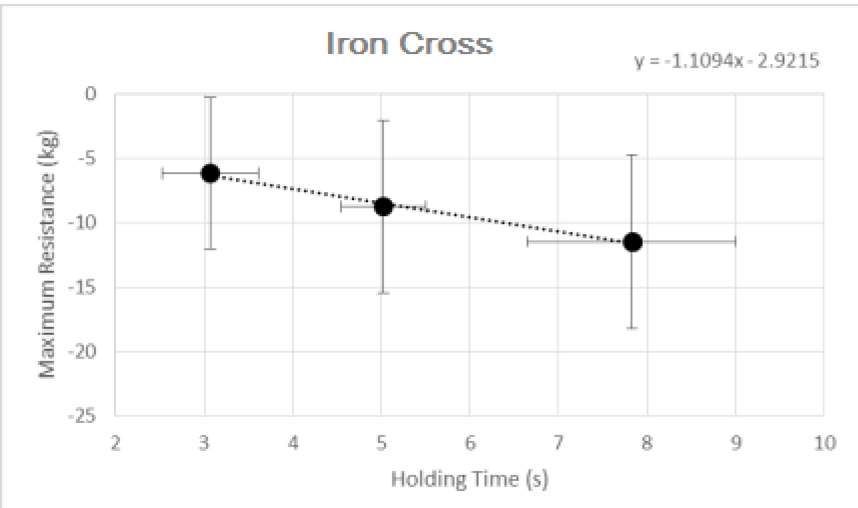


Figure 8. Mean values of the MR, the effective holding times, regressions and simple equation formulas.

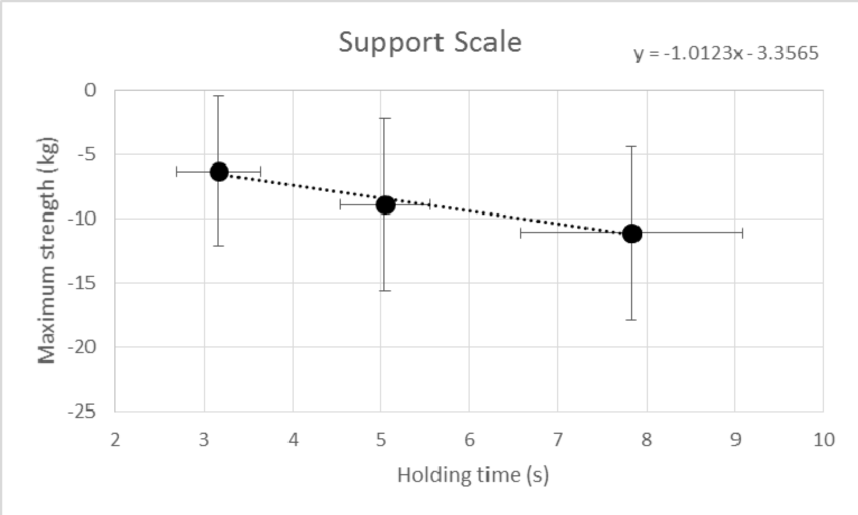


Figure 9. Mean values of the MR, the effective holding times, regressions and simple equation formulas.

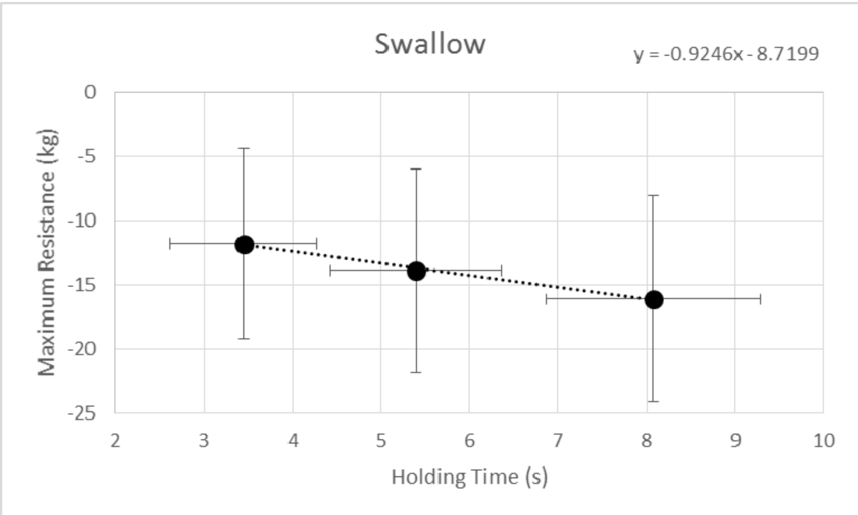


Figure 10. Mean values of the MR, the effective holding times, regressions and simple equation formulas.

Table 2
Mean values of the MR, the effective holding times, regressions and simple equation formulas.

	Iron Cross		Support Scale		Swallow	
Holding time	5s	7s	5s	7s	5s	7s
MD (%) of MR	96.3%	92.2%	96.6%	92.9%	96.5%	92.8%
(SD)	*(1.6%)*	*(3.4%)*	*(1.1%)*	*(2.5%)*	*(1.3%)*	*(2.9%)*
R^2	0.92	0.88	0.99	0.98	1	0.96
SEE (kg)	1.03	1.81	0.82	0.95	0.52	1.69

Table 3
MR for the three, five and seven seconds holding time prediction.

Iron Cross	Support Scale	Swallow

Time	3s	5s	7s	3s	5s	7s	3s	5s	7s
Maximum Resistance (kg)	5.00	3.00	0.00	5.00	2.00	0.00	5.00	3.00	2.00
	4.00	2.00	-1.25	4.00	1.00	-1.25	4.00	2.00	1.00
	3.00	1.00	-1.25	3.00	0.00	-1.25	3.00	1.00	0.00
	2.00	0.00	-2.50	2.00	0.00	-2.50	2.00	0.00	-1.25
	1.00	-1.25	-3.75	1.00	-1.25	-3.75	1.00	0.00	-2.50
	0.00	-2.50	-5.00	0.00	-2.50	-5.00	0.00	-1.25	-3.75
	-1.25	-3.75	-6.25	-1.25	-3.75	-6.25	-1.25	-2.50	-5.00
	-2.50	-5.00	-7.50	-2.50	-5.00	-7.50	-2.50	-3.75	-6.25
	-3.75	-6.25	-8.75	-3.75	-6.25	-8.75	-3.75	-5.00	-7.50
	-5.00	-7.50	-10.00	-5.00	-7.50	-10.00	-5.00	-6.25	-8.75
	-6.25	-8.75	-11.25	-6.25	-8.75	-11.25	-6.25	-7.50	-10.00
	-7.50	-10.00	-12.50	-7.50	-10.00	-12.50	-7.50	-8.75	-11.25
	-8.75	-11.25	-13.75	-8.75	-11.25	-13.75	-8.75	-10.00	-12.50
	-10.00	-12.50	-15.00	-10.00	-12.50	-15.00	-10.00	-11.25	-13.75

The means of MR for all elements decreased significantly with increasing holding time (t-Test: $p < 0.001$). The mean decline of MR based on the MR at three seconds (= 100 %) showed very similar values for all elements but indicated smaller SD at the five than the seven seconds holding time.

The very high values of the explained variance (R^2) showed stronger relationships between the measured and predicted values of MR at the five than the seven seconds holding time for all elements.

The standard error of estimate (SEE) between the calculated and measured values revealed higher accuracy at the five than at the seven seconds holding time (table 2).

Based on the previously calculated linear regression equations for the elements C, SS and S (Figures 8 to 10) and the MR of the three seconds holding time, MR for the five and seven seconds holding time were predicted, yielding the following conversion table (table 3).

DISCUSSION

In this study, the predictability of the MR, expressed as minimal counterweight or maximal additional weight, of the elements Iron Cross, Support Scale and Swallow on the rings at five and seven seconds based on the three seconds holding time MR in a specific static maximal strength test was examined.

As expected the MR decreased significantly with increasing holding times for all elements. For all elements, increasing the holding time from three to five seconds leads to a decrease in MR of 3.5 % to 3.7 %. Increasing the holding time to seven seconds reduces the MR by 7.2 % to 7.8 % compared with the three seconds holding time. These results correspond with the findings of Simkin (1959) and Kamimura & Ikuta (2001), who found a gradual decrease of maximal isometric grip strength ratios every second. The reason for this might be explained by the high intensity of maintaining these static elements (Rozand, Cattagni, Theurel, Martin & Lepers, 2015).

The results reveal a generally higher predictability of the MR at the five than the seven seconds holding time, for all elements. These findings are comparable to those of Reynolds, Gordon and Robergs (2006) and Brechue and Mayhew (2009), who found a higher predictability of the 1RM from lower repetition maximum testing than from 10 or more repetitions.

The calculations of MR at the element S showed small variance and high predictability due to the homogenous performances. Only two athletes had training experiences with this element. Moreover, all athletes except one had to use a counterweight to reach the required holding times.

The prediction of MR for the element SS shows the highest accuracy at the five and the seven seconds holding time. Especially the very low SEE at seven seconds is noteworthy. Thus, in general the discrepancies between predicted and real weight shouldn't exceed one kilogram.

The Iron cross was the only element where the deviation between measured and predicted weight at five seconds was greater than one kilogram. Six athletes (athlete 2 to 8) in this study showed the element Iron Cross in their competitive routine and they were accustomed to its intense load. They tended to use more additional weight for the five and seven seconds holding time than predicted. However the other three gymnasts with less training experience had a much higher decrease of MR with increasing holding time. One reason for this could be that the athletes are not used to the strain on the shoulder, which in turn influences stamina and leads to a higher chosen counterweight. According to Zatsiorsky & Kraemer (2006) isometric strength training might be painful if the athlete isn't able to maintain the holding position of the element (eccentric phase at the end of the holding time if the chosen intensity is too high). Furthermore these authors consider isometric strength training only as a complementary method to the usual concentric exercises, because maximum strength only increases slightly and only during the first six to eight weeks. But as isometric contractions improve the strength level particularly at the angle at which they are executed, and the training of the hold elements is necessary to develop the technical skills (muscle coordination and efficiency of muscle innervation during the static holding), the training of the static hold position is crucial for developing the required strength for elements on rings (Hesson, 1985). In accordance with the findings of Starischka (1978) and Starischka and Tschiene (1977), who observed a significant improvement of the Iron Cross-specific MR if the hold element is trained at 90 % of maximum intensity, reducing the intensity by varying the holding time might be an interesting way to vary the training stimulus (volume and intensity) while also protecting the gymnast's joints from overload or injury.

Nevertheless, the prediction of the MR at increased holding times is highly accurate and does not differ much more than the smallest possible weight increment on average. Therefore it is admissible to calculate a conversion table based on the obtained regression equations, to predict the MR at five and seven seconds holding time. If individual variation appears in training, the resistance has to be adjusted individually.

In order to get more detailed findings regarding the individualization of the rings-specific training, follow-up studies should focus on the use of surface electromyography (EMG) during holding elements. The detection of the main holding-muscles, the muscle activation patterns and the inter-individual differences between top- and lower-level gymnasts would be of interest. Subsequently, the effectiveness of any specific strength training method could be determined more precisely.

CONCLUSIONS

In summary

- The MR diminishes significantly ($p < 0.001$) for all elements with increasing holding time. Based on the MR at the three seconds holding time, the MR decreases by 3.5 – 3.7 % at five and by 7.2 – 7.8 % at seven seconds holding time.
- The prediction (R^2 and SEE) of the MR (based on the MR at three seconds) for all elements is more accurate at five (R^2: C: 0.92; SS: 0.99; S: 1.00, SEE: C: 1.03 kg; SS: 0.82 kg; S: 0.52 kg) than seven seconds (R^2: C: 0.88; SS: 0.98; S: 0.96, SEE: C: 1.81 kg; SS: 0.95 kg; S: 1.69 kg).
- With help of the linear regression equations, a useful conversion table was calculated to predict the MR at five and seven seconds holding times based on the MR at three seconds (Table 3). Subsequently, the coaches only have to

estimate the MR at three seconds holding time.

• A certain individual variation between the real and predicted weight cannot be excluded, especially for the seven seconds holding time and for athletes with little or no experience with this sort of specific strength training.

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Corresponding author:

Christoph Schärer, MSc
Swiss Federal Institute of Sports
Magglingen (SFISM),
Switzerland, CH-2532
Tel: +41323276504
E-mail: christoph.schaerer@baspo.admin.ch

EFFECTS OF ISOKINETIC RESISTANCE TRAINING ON STRENGTH KNEE STABILIZERS AND PERFORMANCE EFFICIENCY OF ACROBATIC ELEMENTS IN ARTISTIC GYMNASTICS

Muhamed Tabaković[1], Almir Atiković[2], Elvir Kazazović[1], Senad Turković[1]

[1] University of Sarajevo, Faculty of Sport and Physical Education, Bosnia and Herzegovina
[2] University of Tuzla, Faculty of Physical Education and Sport, Bosnia and Herzegovina

Original article

Abstract

The aim of this study was to examine whether additional training protocol of isokinetic training results in increased biomechanical values of certain parameters and whether it increases functional correlation between speed and strength leading to improved performance of acrobatic elements in floor exercises. Additional training protocol, which lasted for one semester, was performed on Biodex 3 apparatus (60°·s^{-1}). Examinees participating in this research were (N = 80) male students from Faculty of Sport and Education (mean age, 19.8 ± 1.7 year; weight, 75.2 ± 2,9 kg; height 179.7 ± 6.4 cm). Control group (N = 40), between two measurements, conducted only regular practical teaching program of artistic gymnastics. Experimental group (N = 40), besides regular practical teaching program of artistic gymnastics, also had additional program of isokinetic practice on Biodex 3 apparatus. Experimental group showed obvious structural changes that can be dominantly registered through variables assessing the maximum strength of the dynamic knee stabilizers (the maximum moment of force, overall work and average strength) and reciprocal relationship between agonist and antagonist muscles. In variables assessing the performance of elements of floor exercises in artistic gymnastics we obtained statistically significant differences in elements requiring changes of the maximum strength of the dynamic knee stabilizers: dive roll, back handspring, salto forward and backward tucked.

Keywords: *isokinetic, peak torque, power, work, acrobatic elements.*

INTRODUCTION

Sport gymnastics is classified in the group of conventional sports (Čuk, 1996), considering that the aesthetic component and acyclic movement are based on strict rules of the Code of Points (Fédération Internationale de Gymnastique, 2013). 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). Acrobatic elements have a significant influence on the ability to move the body in space (Bressel, Yonker, Kras, & Heath, 2007), which improves overall coordinative motor ability of the entire body and its parts (Bolkovič, & Kristan, 1998). Also, very accurate and fast work and alternating activation of individual muscles and muscle groups, acrobatics develop all forms of strength, where the explosive and static strength is the most important especially in the take off phase and landing (Marinšek, 2010).

As an example, in artistic gymnastics requires a high level of physical fitness and skill to succeed: speed (Lindner, Caine, & Johns, 1991), strength (Lindner, Caine, & Johns, 1991; Bradshaw, & Le Rossignol, 2004), endurance (Bradshaw, & Le Rossignol, 2004), agility (Daly, Bass, & Finch, 2001), flexibility (Delaš, Babin, & Katić, 2007), balance (Lindner, Caine, & Johns, 1991) and power (Delaš, Babin, & Katić, 2007) are all physical abilities that play a role in the success of a competitive gymnast.

In artistic gymnastics on floor exercies some phases like run, take off, flight and landing phase success depends on the physical preparation and motor control of the gymnast. Physical preparation refers to the gymnast's ability to cope with the load to which they are exposed during the take off and landing. Motor control refers to the control the gymnast has over the skill they perform (Marinšek, 2010). During take-offs and landings in artistic gymnastics can be very high. Forces measured at landings can range from 3.9 to 14.4 times the gymnast's body weight (Panzer, 1987; Karacsony, & Čuk, 2005). Based on previous studies by Karacsony and Čuk (2005) found that forces at take off at different somersaults can be up to 13.9 times the participant's body weight.

Different preparation drills using modern props for the development of motor skills are used. They have to emulate as authentically as possible the movement structure of an element that is learned and practiced. They have to influence development and improvement of motor abilities that are necessary for its performance and therefore are performed with the same or similar amplitude and direction of muscle contraction. Majority of preparation drills are done individually, with the help of a training prop or a coach. Therefore, all coaches as well as gymnasts have to be experts in the movement structure they teach and they have to know which muscle groups are specific for certain acrobatic elements.

Isokinetic training requires a special machine that keeps the muscle contracting at a constant pace. Isokinetics combine isometric and isotonic contractions. This kind of training allows for maximal strength improvements and is usually combined with other types of strength training. Because the equipment used in isokinetic training constantly monitors the exertion of the user, the resistance can be altered to keep a constant contraction on the muscles without risk of overtraining or injury. This type of training is especially helpful in rehabilitation scenarios where the person is at high risk for re-injury. Isokinetic dynamometers are used widely for trening, testing and rehabilitation in various sports and injuries (Dvir, 2004). Reliability (Siqueira, Pelegrini, Fontana, & Greve, 2002) and validity (Siqueira, Pelegrini, Fontana, & Greve, 2002; Pincivero, Dixon, & Coelho, 2003) of isokinetic torque measurement were reported good to excellent while reliability in lower velocities reached high (Pincivero, Dixon, & Coelho, 2003). Popular isokinetic velocities are $60°\cdot s^{-1}$, $180°\cdot s^{-1}$, and $300°\cdot s^{-1}$; these are often referred to as slow, medium, and fast speeds, respectively. Selecting low strength speed ($60°\cdot s^{-1}$), medium fast speed ($180°\cdot s^{-1}$) and high endurance speed ($300°\cdot s^{-1}$) isokinetic testing speeds is essential for optimal strength evaluation, given that in slow muscle action the vast majority of motor units are recruited, while faster testing velocities enrich the force-velocity spectrum of the acting muscles (Baltzopoulos, & Brodie, 1989).

In this article (Benson, 2008), the term “resistance training” is defined as a type of exercise that requires the musculature to contract against an opposing force generated by some type of resistance (e.g., body weight, barbells, dumbbells, weight, isokinetics machine).

However, motor performance increases observed during resistance training are: vertical jumping ability, sprinting speed, balance, coordination, throwing velocity, kicking performance, running economy, bat swing velocity, wrestling performance, tennis service velocity, etc. (Kraemer, Ratamess, & French, 2002). The key quality to an individualized resistance training program is the acute manipulation of program variables targeting certain areas of muscular fitness. The program variables are: 1) intensity (or loading), 2) volume (the number of sets and repetitions), 3) exercises selected, 4) the order of the exercises, 5) rest intervals between sets, 6) velocity of contraction, and 7) frequency (Kraemer, Ratamess, & French, 2002).

METHODS

This investigation was designed to assess the possible beneficial effects of isokinetic training on students who attend practical classes from artistic gymnastics. During gymnastic exercises on floor, considerable force output is required in the knee muscles. Isokinetic performance of the knee muscles in students population, has not been examined. Our study provides important information related to adaptations of this group muscle training that occur in students population of Physical Education and Sport. The reason why we decided to try this kind of study is to compare our results resistence traning with other similar studies (Calmles et al., 1995; Teng et al., 2008; Piazza et al., 2014). So far we have not found studies showing the effect of short-term exercise on the student population and that would help students when adopting new motor skills.

The study was performed in accordance with the ethical standards. Moreover, the local Ethics Committee, in accordance with the Helsinki Declaration, approved all procedures prior to the start of this investigation. All volunteers completed a medical screening questionnaire and provided written informed consent prior to participation. The participants in this research consisted of (N=80) male students of the Faculty of Sport and Physical Education, University of Sarajevo, (mean age, 19.8 ± 1.7 years; weight, 75.2 ± 2.9 kg; height, 179.7 ± 6.4 cm). The participants were divided, using accidental sampling method, into two groups: control C (N=40) and experimental E (N=40). The entire experiment was conducted during one semester of the academic year.

Strength test on knee joint extensor an flexor was conducted using Biodex System 3 (Biodex Corporation, Shirley, New York, USA) isokinetic dynamometer (Fig. 1). Reliability of the system expressed in coefficient of variation is 3 % (Drouin, Valovich-mcLeod, Shultz, Gansneder, & Perrin, 2004). Short and brief introduction to Biodex Pro 3 system and its software (Biodex System 3, 2009). In this additional programmed kinesiology treatment the machine was used for exercise in experimental group.

Examiners in this study are University professors (N=3) with more than 30 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). Only better performance of performed 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 examiner. For evaluation, they used points from 6 to 10 point measuring scale, according to the criteria, where grade 10 is the highest/best.

Anthropometric tests: Body height – BH was measured using Martin's anthropometer with precision of 0.1 cm.

Examinees were on the horizontal surface standing on one leg, with body weight equally balanced on both legs, shoulders relaxed, heels placed together, while the head was in so called „frankfurt plane“. Total body weight – BW (kg), was measured using a Tanita TBF-300A Pro Body Composition analyzers scales with precision of 0.1 kg. Students and students were barefooted during measurements.

All measurements of the strength of knee joint extensors and flexors were performed from sitting position with 90° average angle of body and upper leg. Bands for stabilization were positioned over body, hips and distal part of upper leg for the leg that was tested. During the whole procedure of isokinetic training examinees held their hands crossed on their chests. Also, during the test examinees were given instructions that they have to give their maximum effort for each exercise. Dominant leg was always the first one to be tested. Dominant leg was considered to be the one that examinees chose to be the leg they would use to kick the ball. By this way leg dominance was determined in other studies as well (Wei, Housh, Housh & Weir, 1997.)

Table 1
Criteria for acrobatic elements knowledge evaluation.

Measurement scale (points)	Description of standards - Acrobatics
Points 10	The exercise (element) is performed optimally in such a way that there were no mistakes in the initial position, body position, leg and/or hand positions. There were no mistakes in the aesthetic part of the exercise, in the coordination of performance, technical performance, range of motion, in the speed and pace and lastly no mistakes in the final position.
Points 9	The exercise (element) was performed optimally with minor errors found in certain technical requirements of the initial position, body position, and position of the legs and/or hands. Possible minor errors found in the aesthetic part of the exercise, range of motion, speed and pace and final position. Total maximum number of minor faults 1 to 2.
Points 8	The exercise (element) is still well-performed with a small number of errors noticed in certain technical requirements of the initial position, body position, and position of the legs and/or hands. Possible errors found in the aesthetic part of the exercise, coordination of performance, range of motion, speed and pace and final position. However these errors did not impair the whole structure of the movement. The total maximum number of minor errors 3 to 4.
Points 7	The performance of the exercise (element) was flawed. There were errors in almost all the above mentioned technical requirements. There was also a noticeable distortion in the structure of the movement.
Points 6	The exercise (element) is poorly performed with a large number of errors. There are major deficiencies in all of the abovementioned technical requirements. The structure of the movement was significantly impaired.

Table 2
Resistance training programme.

Exercise	Sets/Repetitions/Rest	Speed
	Warming up on byciclogometer 10 min (75 RPM, 50 WATT)	
	Static stretching muscles of lower extremities (10 min)	
3 sets	4 - 6 repetitions pauses of 30 s between the series	with the left leg on the angular speed of $60°\cdot s^{-1}$
3 sets	4 - 6 repetitions pauses of 30 s between the series	with the right leg on the angular speed of $60°\cdot s^{-1}$
	Pause between exercises of 3 min	

Table 3
Artistic gymnastics elements.

DRL – dive roll	
CAR – cartwheel	
FHS – front handspring	
BHS – back handspring	
SFT – salto forward tucked	
SBT – salto backward tucked	

A standardized testing routine improves the operator's control of several variables that influence tests: testing of uninvolved side first, alignment of axis of rotation, warm-ups, subject stabilization, verbal commands, visual feedback, test position, system calibration, angular velocity selection, system stabilization, skill, training of tester, gravity compensation, rest intervals, test repetitions, collection of data (print - out) for future analysis, analysis of data through the use of statistical software (Biodex 3, 2009).

Testing protocol for isokinetic assessment in this research:

Body height and weight was measured for each participant before initial and final measurement.

Warm-up and overall body stretching – 20 min.

Positioning examinee in optimal stabilization.

Alignment of joints and dynanometric axis of rotation.

Positioning pad for resistance.

Verbal introduction into isokinetic concept of exercises.

Gravitation correction.

Warm-up (3 submaximal, 1 maximal repetitions).

Maximal test with the test speed 60 (5 repetitions).

Rest (30 seconds).

Testing contralateral extremity.

Recording test detail to make sure that repeatability on a repeated test is possible.

The experimental group of subjects had an isokinetic program (Table 2) of exercise 3 times a week x 40 min for 12 weeks. All subjects had a knee range of motion (ROM) 90 degrees. Testing speeds for the knee were set at $60°·s^{-1}$ for concentric and eccentric muscle action.

Variables to assess maximum muscle strength of the dynamic knee stabilizers

The following section will define the test data, and describe what may affect each variable (Biodex System 3, 2009). Peak torque (PT) highest muscular force output at any moment during a repetition expressed in (Nm). Peak Torque indicates the muscle's maximum strength capability. Variables show results separately for extension and flexion and for left and right leg. Total work (TW) the amount of work accomplished for the entire set. This represents the muscle's capability to maintain torque throughout the test bout. If the ROM is smaller on one side, the total work will be affected even if the peak torque is the same.

Average power (AVG power)

AVG power = amount of total work divided by the time to complete that total work. This value is used to provide a true measure of work rate intensity defined as total work divided by time. Power represents how quickly a muscle can produce force. It expresses the muscle's ability to do the work for a specified period of time and intramuscular ratio (agonist to antagonist ratio) is expressed in percentages for both legs (Biodex System 3, 2009).

Maximum muscle strength of knee extensors

EXTLEF60 (Nm) – peak torque of the knee extensors of the left leg

EXTRIG60 (Nm) – peak torque of the knee extensors of the right leg

EXLFTW60 (J) – total work of the knee extensors of the left leg

EXRGTW60 (J) – total work of the knee extensors of the right leg

AVGEXLF60 (W) – average power of the knee extensors of the left leg

AVGEXRG60 (W) – average power of the knee extensors of the right leg

Maximum muscle strength of knee flexors

FLXLEF60 (Nm) – peak torque of the knee flexors of the left leg

FLXRIG60 (Nm) – peak torque of the knee flexors of the right leg

FXLFTW60 (J) – total work of the knee flexors of the left leg

FXRGTW60 (J) – total work of the knee flexors of the right leg

AVGFLLF60 (W) – average power of the knee flexors of the left leg

AVGFLRG60 (W) – average power of the knee flexors of the right leg

Ratio between knee extensors and flexors

AGANLF60 – intramuscular ratio (hamstring/quadriceps) of the left leg

AGANRG60 – intramuscular ratio (hamstring/quadriceps) of the right leg

Variables to assess the efficiency of the performance of floor exercises elements of artistic gymnastic

The participants did not have prior knowledge of applied artistic gymnastics; therefore the initial assessment of the performance of the artistic gymnastics was not carried out. However after the basic program of 12 weeks of regular practical training – a final evaluation of the experimental and control groups was conducted by the University professors (N=3) with more than 30 years of experience of work in various sports clubs and Faculty of Physical Education and Sport. The acrobatic tests, with description of movements and certain mistakes, were used by authors (Mujanović, Atiković, & Nožinović Mujanović, 2014). 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 2 m long and 1 m wide with height/thickness of 6 cm. The sample of variables to assess the efficiency of the performance of floor exercises elements of competitive gymnastics is represented in this research by six elements (Table 3).

Statistical analyses

Descriptive statistics (means and standard deviation) was calculated for all variables separately for each group. ANOVA was performed to determine whether there were significant differences. Data were analyzed using oneway ANOVA with repeated measures. All variables in each sample had normal disrubition which is tested by Kolmogorov – Smirnov test. There were no significant differences between control and experimental gymnastics group. Significant level was defined as ($P < 0.05$). The SPSS version 21.0 was used for all analyses (SPSS Inc., Chicago, Illinois).

RESULTS

All the participants completed the study and no injuries or health complains were reported. In (Table 4) contains results of arithmetic means and standard deviation for variables body height and body weight for examinees from control and experimental group in initial and final measurement. By going through the results, one can conclude that there are no differences of artihmetic means in results of the applied variables. Average values of body height for control and experimental group were calculated, and they were within the following range (C: 179.13 ± 5.97; E: 180.20 ± 7.01) while the values for body weight was (C: 74.90 ± 3.13; E: 75.80 ± 2.85). The same calculation was done before the second measurement, with the value for body height being (C: 179.24 ± 5.95; E: 180.43 ± 6.91), and body weight (C: 74.76 ± 2.93; E: 75.55 ± 3.00). From a statistical point of view, there were no differences between the two groups.

Table 4
Comparison two variables after the first and second measurement (Mean ±SD).

Variable	Control Group Mean ± SD (N=40)	Experimental Group Mean ± SD (N=40)	*P* Value for Group Difference	Control Group Mean ± SD (N=40)	Experimental Group Mean ± SD (N=40)	*P* Value for Group Difference
	Fisrt measurement			Second measurement		
Height (cm)	179.13 ± 5.97	180.20 ± 7.01	.46	179.24 ± 5.95	180.43 ± 6.91	.41
Weight (kg)	74.90 ± 3.13	75.80 ± 2.85	.18	74.76 ± 2.93	75.55 ± 3.00	.24

Data are presented as the Mean ± SD. *P* values based on comparisons of groups using ANOVA.

Table 5
ANOVA dynamic stabilizer knee control and experimental groups in the initial and final measurements (speed 60°·s^{-1}).

Variable	First measurment	Second measurment	df	F (First measurment)	P Value for Group Difference (First measurment)	F (Second measurment)	P Value for Group Difference (Second measurment)
	Mean ± SD			ANOVA			
Maximum muscle strength of knee extensors							
EXTLEF60	216.46 ± 38.62 219.94 ± 37.78	266.17 ± 41.37 231.43 ± 39.82	1.00	0.17	.69	14.64	.00*
ETRIG60	209.14 ± 32.70 221.67 ± 35.48	258.35 ± 41.94 223.83 ± 36.17	1.00	2.70	.10	15.55	.00*
EXLFTW60	890.20 ± 175.01 950.89 ± 182.91	1141.22 ± 206.32 969.57 ± 147.09	1.00	2.30	.13	18.36	.00*
EXRGTW60	874.13 ± 121.97 911.66 ± 113.00	1130.36 ± 215.46 942.15 ± 156.70	1.00	2.04	.16	19.96	.00*
AVGEXLF60	134.04 ± 19.68 137.08 ± 17.45	176.49 ± 40.90 147.04 ± 26.90	1.00	0.54	.47	14.48	.00*
AVGEXRG60	125.18 ± 11.87 128.76 ± 15.03	172.09 ± 44.51 143.80 ± 27.07	1.00	1.40	.24	11.80	.00*
Maximum muscle strength of knee flexors							
FLXLEF60	120.33 ± 13.03 123.98 ± 10.88	150.32 ± 23.84 131.79 ± 23.98	1.00	1.85	.18	12.02	.00*
FLXRIG60	131.42 ± 20.82 135.38 ± 23.59	149.57 ± 25.15 131.50 ± 24.97	1.00	0.63	.43	10.40	.00*
FXLFTW60	511.10 ± 57.91 498.47 ± 64.84	790.87 ± 142.74 664.45 ± 134.15	1.00	0.84	.36	16.66	.00*
FXRGTW60	557.72 ± 70.75 541.70 ± 78.80	800.44 ± 137.64 657.00 ± 146.93	1.00	0.92	.34	20.30	.00*
AVGFLLF60	91.29 ± 6.56 92.77 ± 6.98	115.76 ± 23.83 94.93 ± 21.13	1.00	0.96	.33	17.10	.00*
AVGFLRG60	93.18 ± 17.22 91.69 ± 12.99	118.44 ± 26.19 94.18 ± 20.83	1.00	.19	.66	21.03	.00*
Ratio between knee extensors and flexors							
AGANLF60	55.06 ± 4.07 56.54 ± 6.58	59.21 ± 3.27 57.33 ± 7.21	1.00	1.47	.23	2.27	.14
AGANRG60	59.03 ± 6.43 61.24 ± 8.00	61.13 ± 3.68 58.98 ± 7.39	1.00	1.86	.18	2.71	.10

Data are presented as the Mean ± SD. *P* values based on comparisons of groups using ANOVA.
*. The mean difference is significant at the .05 level

Table 6
ANOVA elements of acrobatics for control and experimental group.

	ANOVA					
Variable	Mean ± SD	Sum of Squares	df	Mean Square	F	*P* Value for Group Difference
DRL – dive roll	8.28 ± 0.96 7.00 ± 0.68	32.51	1.00	32.51	46.98	.00
CAR – cartwheel	8.20 ± 0.72 8.03 ± 0.70	.61	1.00	.61	1.21	.27*
FHS – front handspring	7.85 ± 0.74 7.78 ± 0.70	.11	1.00	.11	.22	.64*
BHS – back handspring	7.90 ± 0.78 6.90 ± 0.67	20.00	1.00	20.00	37.86	.00
SFT – salto forward tucked	7.80 ± 0.72 6.58 ± 0.71	30.01	1.00	30.01	58.27	.00
SBT – salto backward tucked	7.70 ± 0.76 6.45 ± 0.64	31.25	1.00	31.25	63.64	.00

Data are presented as the Mean ± SD. *P* values based on comparisons of groups using ANOVA.
*. The mean difference is significant at the .05 level

The first analysis was done on the results of control and experimental group in the initial measurement, in other words before the program was conducted. In (Table 4.) one can see the results which show that from a statistical point of view examinees are not significantly different in all strength variables of flexor muscle and dynamic knee stabilizer. Based on this one can conclude that differences are statistically insignificant or in other words that the two groups of examinees belong to the same population. ANOVA showed that significant difference was found for all variables the maximum muscle strength of knee extensors and the maximum muscle strength of knee flexors between unspecific and specific training program on Biodex 3 ($P < 0.05$). Results ANOVA showed that there were no statistically significant changes after the second measurement in the two variables that were treated (Ratio between knee extensors and flexors) in AGANLF60 ($F_{1.80} = 2.27$; $P < 0.14$), and AGANRG60 ($F_{1.80} = 2.71$; $P < 0.10$).

In two variables (Table 6) assessing the success in performing elements of floor exercises in artistic gymnastics: CAR – cartwheel and FHS – front handspring, we obtained no statistically significant differences in relation to control and experimental group CAR ($F_{1.80} = 1.21$; $P < 0.27$), and FHS ($F_{1.80} = 0.22$; $P < 0.64$). Reason for this may be the fact that in elements cartwheel and front handspring, take off is performed from arms to legs, with arms being more important in the performance of the element in comparison to other elements performed by a take off using lower extremities.

DISCUSION AND CONCLUSION

Our wish was to determine not only whether additional training protocol results in the increased biomechanical values of certain parameters but also to determine whether isokinetic training or resistance training increases functional correlation between speed and strength leading to improved performance of acrobatic elements in floor exercises. We designed and evaluated training protocol and found that it is effective in increasing the strength of knee extensors and flexors. Design of isokinetic dynamometer on apparatus Biodex 3 allows continuous resistance in all angles of movement that other training simulators don't possess. This characteristic is important not just for a significant increase in muscle strength but also to balance the relationship between flexor and extensor muscles of the dynamic knee stabilizers.

Control group had more unfavourable position than experimental group because between the two measurements for control group only regular program of practical teaching from competitive gymnastics was conducted without additional training program. In the program which entities from control group were subjected to there were no additional stimuli such as training on apparatus Biodex 3, which made the whole process completely directed to regular practical teaching on college. Therefore, structural changes of the maximum strength of the dynamic knee stabilizers with lower intensity occurred for control group. Experimental group showed obvious structural changes which could be dominantly registered through variables for the assessment of the maximum strength of the dynamic knee stabilizer (the maximum moment of force, overall work and average strength) and reciprocal relationship between agonist and antagonist muscles.

In the initial measurement, before we started conducting the program, the groups practically show no differences, which is an excellent indicator of balanced position for possible application of specific additional training program for muscles of the dynamic knee stabilizers under two applied transformational procedures. However, in the second measurement (at the end of program) the groups show significant differences in the assessment of the maximum strength of the dynamic knee stabilizers as well as in the assessment of the performance of floor exercise elements in competitive gymnastics.

In variables assessing the maximum strength of the dynamic knee stabilizers and variables assessing the performance of floor exercise elements in competitive gymnastics we obtained statistically significant differences in almost all applied variables.

Our findings determined that for elements of floor exercises in artistic gymnastics it can be concluded that more significant were the changes obtained for elements that required changes of the maximum strength of dynamic knee stabilizers: dive roll, back handspring, salto backward and forward. Explosive strength, which is defined as the ability to activate the maximum number of muscle units in the unit of time, in majority of researches has significant correlations with the success in performing floor exercise elements and elements of other sports (Mujanović, Atiković, & Nozinović Mujanović, 2014; Lešnik, Glinsek, & Žvan, 2015). Above mentioned facts lead to a conclusion that for a successful performance of applied elements in floor exercises for this type of performance, more significant engagement of musculature is necessary on the principle of transitory activation of the maximum number of muscle units in the unit of time (explosive strength of lower extremities).

Preparing additional training on the dynamic knee stabilizers (but probably on many other types of muscles) through training protocols on isokinetic equipment would prove to be the best solution, first of all because of the possibility of optimum training load for a performer and continuous resistance which is allowed by this equipment (Cools, Geerooms, Van den Berghe, Cambier, & Witvrouw, 2007; Teng, Keong, Ghosh, & Thimuryan, 2008).

Certainly, precise defining of sorts and types of protocol, number of repetitions about dependence on transformation stages and aims of work, overall volume and specific content, should all be developed in accordance with the characteristics of muscle groups, which is a topic for future researches, but it is completely certain that the applied training in this research eventually proved to be an important method for improving muscle strength of the dynamic knee stabilizers, as well as significant influence on the improvement of effectiveness in performing elements of floor exercises in competitive gymnastics. Controlling, managing and distributing training load is an important factor not just in terms of intensifying teaching process, but also in bringing the process of additional training closer to authentic problems of students. This happens mostly due to the fact that the influence of adequate kinesiological operators in appropriate time and space (which implies conducting defined control, management and distribution of the load) leads to positive changes in motor abilities and motor skills occur. In other words, adaptational changes in part occur in muscles. This also has a positive influence on creating favorable adaptational structures, and on better overall functional state of students' bodies. It is clear that such students adapt better on the load during the teaching process, but also that the injury chances due to low muscle strength would decrease. Therefore, the overall effects of solving various motor tasks would be larger. Recent findings (Piazza et al., 2014), conversely, have demonstrated that resistance training can be an effective tool to increase strength in children and adolescents, when appropriately prescribed and supervised (Payne, Morrow, Johnson, & Dalton, 1997; Harries, Lubans, & Callister, 2012). The main finding of this study (Piazza et al., 2014), was that both tested resistance training protocols affected positively the jumping performance in young rhythmic gymnasts, with anincrease of 6-7% in lower limb explosive strength and with no side effects. Results are in agreement with other studies which reported statistically significant increases in explosive strength ranging from 5% to 24% as assessed by vertical jumps, after resistance training (Alves, Rebelo, Abrantes, & Sampaio, 2010).

Other reports indicated that resistance training may improve motor performance; strength of the muscles, ligaments and bones in youth. In addition, resistance training helps to prevent or reduce injuries in sports and recreational activities and may favourably alter selected anatomic and psychosocial variables (Faigenbaum, Westcott, Loud, & Long, 1999). Resistance training has become popular among prepubescent and adolescents over the last decade and has received attention as an important component of youth fitness programme (Picosky, Faigenbaum, Westcott, & Rodriguez, 2002).

Some studies have reported that loads of 45-50% of 1 repetition maximum (1RM) in adults, young men and women, has lead to an increase in dynamic muscular strength following 7 to 20 weeks of resistance training at a rate of 3 days per week (Weiss, Coney, & Clark, 1999). It appears that resistance training frequency of twice per week was sufficient to can induce strength gains in adolescents.

This studie (Amato, Lemoine, Gonzales, Schmidt, Afriat, & Bernard, 2001) reported a significant influence of age and physical activity on isokinetic characteristics of hamstring and quadriceps muscles of young gymnasts and soccer players. The isokinetic values of soccer players were significantly higher ($P < 0.0001$) than those of the the gymnasts. The isokinetic values of the oldest gymnasts were significantly higher ($0.005 < P < 0.05$) for the quadriceps than those of the younger gymnasts. The muscular maturation improves the absolute strength of the older sportsmen in comparison to the younger. Soccer favor most the absolute strength of the inferior member in comparison to the gymnastics.

Based on previous study by (Calmels, vanDenBorne, Nellen, Domenach, Minaire, & Drost, 1995) analyzed the effects of intensive training on young national competition gymnasts have not been established with precision. This, using an isokinetic dynamometer at speeds $60°·s^{-1}$ and $120°·s^{-1}$, the concentric and eccentric isokinetic muscle strength of knee flexors and extensors in a population of nine young national caliber gymnasts. In results authors present eccentric strength is greater than concentric strength, there's no significant difference between dominant and non-dominant limb, and a significant increase of the flexor/extensor peak torque ratio was observed with increasing speed, due to the concentric ratios. These results provide information about the relationship between angular velocity and eccentric muscle strength already reported in previous studies and, in particular, the fact that the knee flexors and extensors behave differently during eccentric and concentric work as the angular velocity increases. Analysis of the flexor/extensor ratio also indicated the absence of specific differentiation of muscle activity despite the intensive level of sports activity and suggests the role of age, or even puberty, in these young gymnasts. This analysis encourages annual follow-up of this population and specific studies concerning the role of hormones and muscle maturation.

Previous research by (Procopio, 2014) highlighted that, impact resistance training performed on nonconsecutive days, following non-linear periodization for 1.5 to 2 hours per week for ten weeks is sufficient to obtain bone mineral density and performance improvements in competitive female adolescent gymnasts. Resistance training resulted in significant improvements in bone mineral density, power and jump height, as well as maximal strength ($P \leq 0.05$).

Previous research investigated the isokinetic variables comparing the right and left body side in two sports group, with dominance on one or both legs, did not differ. No differences were recorded in the H/Q between the right and left legs for any of the subject groups (Zakas, 2006).

Research findings suggest that a majority of resistance training-related injuries in children and adolescents are the result of accidents, improper exercise technique or lack of qualified supervision and instruction (Jones, Christensen, & Young, 2000).

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Corresponding author:

Almir ATIKOVIĆ, Ph.D.
University of Tuzla,
Faculty of Physical Education and Sport,
2. Oktobra 1, 75000 Tuzla
Bosnia and Herzegovina
Phone/fax: +387 35 278536
E-mail: almir.atikovic@untz.ba

EFFECTS OF ANKLE JOINT INJURIES ON BALANCE IN MALE AND FEMALE GYMNASTS

George Dallas, Kostas Dallas

Kapodistrian University of Athens, Department of Physical Education and Sport Science, Athens, Greece

Original article

Abstract

Gymnastics is a sport where there always exists a real and present danger of physical injury. Athletic injury, whether temporary or permanent, is a painfully disruptive and uncontrollable interruption in a gymnast's career. Injuries can have profound negative consequences on a gymnast's balance, with lower limbs injuries constituting the majority of these injuries. The purpose of this study was to assess differences in postural stability between high level male and female artistic gymnasts who suffered ankle sprain injuries (ASI) on either or both legs in the past. Ten female (age = 16.66 ± 3.20 years, mass = 47.30 ± 8.00 kg, height = 158.00 ± 5.75 cm) and ten male gymnasts (age = 22.30 ± 1.77 years, mass = 62.00 ± 3.33 kg, height = 168.50 ± 3.03 cm) volunteered to participate in this single visit study. Participants were measured for Limits of Stability variables (Reaction Time [RT]; Center of Gravity Velocity [MVL]; Directional Control [DCL]; End Point Excursion [EPE]; Maximum Excursion [MXE]) to examine the effect of ASI on postural stability. Limits of Stability (LOS) test were used to examine postural stability of gymnasts using the EquiTest Computerized Dynamic Posturography system. Results indicated that females had significantly less ASI than male gymnasts and recorded significantly lower values in Reaction Time and higher values in Movement Velocity during LOS test. In conclusion, the number of past ASI influence postural control as the musculo-tendinous changes around the ankle lead to a reduction of proprioceptive information and may contribute to the deficient postural control mechanisms after injury. Furthermore, postural control may be affected even after acute ASI resolution

Keywords: *Limits of Stability, Reaction Time, End Point Excursion, Maximum Excursion.*

INTRODUCTION

Gymnasts must perform various skills with a high degree of technical mastery that rely on postural control. Even small disturbances in postural stability adversely affect performance (Vuillerme et al., 2001). Acrobatic elements require a high level of postural stability. Balance is a coordination ability during which the Center of Gravity of the body (CoG) is maintained within its base of support (Blackbum et al, 2000). It is maintained by three integrated sensory processes working together, the visual, vestibular, and somatosensory processes (Horak, Nashner, & Diener, 1990; Liaw, Chen, & Pei, 2008) of which the visual system provides the primary (most important) sensory information (Uchiyama & Demura, 2009). The lack of vision has detrimental consequence on performance (Gill et al, 2001). One of the indicators of balance ability is postural sway, i.e., the amount of CoG, or centre of pressure (CoP) excursion during static stance. As Shaffer & Harrison (2007) reported, postural control represents a complex interplay between the sensory systems and involves perceiving environmental stimuli and responding to oscillation of whole body around the ankle joint in order to maintain the CoG within the base of support. According to Pincivero, Bachmeier, & Coelho (2001), the ability of athletes to recognize the body's position in space as well as sense movement without visual reference, constitutes another type of information called proprioception or kinesthesia. Impaired proprioception (Robbins & Waked, 1998), muscle weakness, and subtalar instability (Tropp, 1986) were identified as contributing factors to chronic instability. One of the tests that can measure the subject's ability to control the position of the CoG is the Limits of Stability test (LOS) that computes the distance of athletes' CoP displacement in the anterior-posterior plane without raising heels or toes or taking a step. With the use of Computerized Dynamic Posturography, one can objectively measure the postural components of balance. LOS test measures volitional control of CoG.

Gymnastics is a sport with the highest child and adolescent injury rate (Singh, Smith, Fields, & McKenzie, 2008) with the floor exercises being the most hazardous event (Marshall, Covassin, Dick, Nassar, & Agel, 2007). For gymnasts, the increased demands of the sports' requirements, such as the extensive load of the musculoskeletal system during the take-off and landing phases, the high intensity and volume of training, the perfection of routines performance e.t.c., predispose participants to an increased risk of injury (Kirialanis, Malliou, Beneka, & Giannakopoulos, 2003; Kirialanis, Dallas, DiCagno, & Fiorilli, 2015) and absences from training sessions and/ or competition (Kirialanis, Malliou, Beneka, & Giannakopoulos, 2003). Findings of Hutchison and Ireland (1995) showed that the most frequently injured body parts in AG were the lower extremities especially the ankle and knee joints with the ankle sprain injuries (ASI) being the most frequent type of injury. In addition, acrobat gymnasts aged 13 years and over are frequently injured in training and competition with the majority of injuries affecting the lower limb with the most significant injury risk being the great number of training per week (Purnel et al, 2010). The most disabling injuries were the knee injuries (Gilchrist, Mandelbaum, & Melancon, 2008).

A lot of studies refer to the role of balance in gymnastic performance. According to Lee and Lin (2007), girls exhibit less postural sway than boys of similar ages, whereas a positive effect on balance in elite rhythmic gymnasts showed after vibration training (Tsopani et al, 2014). Although, previous studies reported that injured lower limbs have a negative effect on balance (Bonfim, Grossi, Paccola, & Barela, 2008; McKeon & Hertel, 2008; Wikstrom, Fournier, & McKeon, 2010), it was not clear if the amount of these injuries influence postural stability. Further, to the best of our knowledge there is no scientific evidence of gender comparison and the influence of postural stability on high level gymnasts with past ASI. The study of Forklin et al (2013) examined the effect of multiple ankle sprains on eleven active collegiate level gymnasts, aged, 16-22 years, and found that subjects were better at detecting movement during passive ankle motion trials of their uninjured ankles than their injured ankles and concluded that multiple injuries to the lateral ankle structures result in significantly reduced kinesthetic ability. However, no comparison was done between their female and male gymnasts. Having identified that previous work does not focus on elite gymnasts with previous ASI and does not differentiate between gender, this study focuses on elite gymnasts with previous ASI and aims at assessing the differences in postural stability between male and female gymnasts. It is believed that this will be of value as a research finding and both for training and for recovery. Since previous findings concluded that the overall incidence rate for injury was 30% higher among men when compared to women (Peck et al, 2013), it was hypothesized that female gymnasts would be more stable than their male counterparts due to their lower number of injuries.

METHODS

Ten female (age = 16.66 ± 3.20 years, mass = 47.30 ± 8.00 kg, height = 158.00 ± 5.75 cm) and ten male gymnasts (age = 22.30 ± 1.77 years, mass = 62.00 ± 3.33 kg, height = 168.50 ± 3.03 cm) volunteered to participate in this single visit study. All gymnasts had 11 to 15 years of experience in training, at least six days per week, 3 to 5 hours per day. The primary researcher interviewed the coaches and participants who reported a) the total number of acute ankle sprains injuries (ASI) (Mean = 2.00 ± 1.03, Females = 1.50 ± 0.34, Males = 2.50 ± 0.71), b) time before (in months) of their last ASI (Mean = 11.20 ± 2.65, Females =11.40 ± 2.80, Males = 11.00 ± 2.62). The gymnasts reported that they a) spent less than 5 days due to past ASI without training and b) had no experience from previous injuries in the lower limbs. One hour prior to the Limits of Stability (LOS) test, a familiarization session and anthropometric measurements were performed. Research purpose and experimental protocol were explained and informed consent was signed by each subject. This study procedure was respectful to ethical principles regarding human experiments set by the Declaration of Helsinki.

Postural Control was examined using the EquiTest Computerized Dynamic Posturography system (NeuroCom, Int., Inc., Oregon). The Computerized Dynamic Posturography (CDP) protocol includes the Limits of Stability (LOS) test. The LOS test measures the gymnast's ability to displace their CoG without losing balance from the center to each of the eight peripheral targets and quantifies the percentage of the maximum distance each gymnast can intentionally displace the COG without losing balance. An illustrative example of LOS assessment from a single participant in the present study may be found in figure 1.

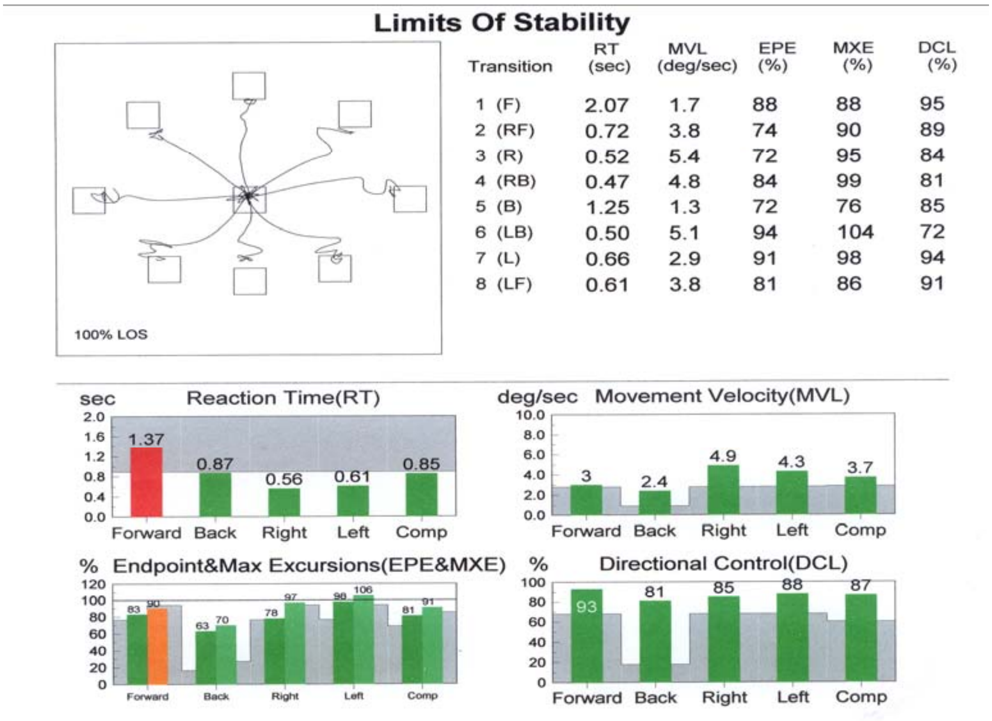

Figure 1. Assessment of Limits of Stability.

In this test, each gymnast shifted the CoG from the center to each of eight peripheral targets, with both feet on the floor. On command, she/he moved the CoG cursor as quickly and accurately as possible towards of the targets located at the limits of stability perimeter and then held a position as close to the target as possible. The LOS measurements, with respect to reaction time (RT), movement velocity (MVL) and end-point excursion (EPE) are presented in Table 1.

The split half method was used to assess the reliability of the postural stability test (LOS), with respect to the RT, MVL and ERE assessments. The results revealed coefficients of .762, .941 and .850 for RT, MVL and EPE, respectively. The construct validity was assessed through multivariate comparisons between the present sample and a separate sample of highly competitive rhythmic gymnasts, without previous experience of ankle injuries (Tsopani et al., 2014). The results provided construct validity evidence since the non injured rhythmic gymnasts had higher scores, compared to artistic gymnasts in the RT ($\Lambda = .544$, $F = 2.752$, $p = .031$, $\eta^2 = .456$), MVL ($\Lambda = .635$, $F = 2.875$, $p = .035$, $\eta^2 = .365$) and EPE ($\Lambda = .352$, $F = 5.064$, $p = .001$, $\eta^2 = .648$) measures, respectively.

A MANCOVA was used to examine gender differences in the postural stability test, while the number of injuries served as a covariate. Univariate ANCOVAs used for post hoc comparisons. The significance level was set at $\alpha = 0.05$.

RESULTS

Female gymnasts showed significantly lower number of injuries than male gymnasts (p= .025). The MANCOVA on LOS test was significant for: **a)** Reaction Time (RT) (Wilk's $\Lambda = .225$, $F = 4.299$, $p = .017$, $\eta^2 = .775$); **b)** Movement Velocity (MVL) (Wilk's $\Lambda = .164$, $F = 6.354$, $p = .004$, $\eta^2 = .836$); and **c)** Endpoint Excursion (EPE) (Wilk's $\Lambda = .213$, $F = 4.628$, $p = .014$, $\eta^2 = .787$). The post hoc ANCOVAs were significant for: **a)** RT in Right Backward direction ($F = 5.614$, $p = .030$, $\eta^2 = .248$), approached significance for RT in Forward direction ($F = 4.341$, $p = .053$, $\eta^2 = .203$), **b)** and were significant for the MVL in Right Forward direction (MVLRF) ($F = 8.159$, $p = .011$, $\eta^2 = .324$). Examination of the adjusted balance mean score in LOS RT in Right Backward direction (LOS RT RB) showed that the group of female gymnasts scored lower than their male counterparts. However, female gymnasts scored higher in MVL Right Forward direction (LOS MVL RF) than their male counterparts. The ANCOVA findings with respect to the injuries (covariate) balance scores and adjusted balance scores for female and male gymnasts are found in table 2.

DISCUSSION

This was the first study on postural stability on artistic gymnasts. Results of the present study revealed that female gymnasts have better postural stability, compared to male gymnasts, with respect to the reaction time right backwards and movement velocity right forward. These findings may be attributed to the effective proprioception of the ankle joints. This finding supports previous data, which showed that Reaction Time (RT) could be one of the supporting factors for better dynamic balance performance (Bressel, Yonker, Kras, & Heath, 2007). Additionally, the lower RT of female gymnasts in the Right-Backward direction may be related to the apparatus requirements. For example, on the balance beam, due to the apparatus dimensions, (female) gymnasts loose balance mostly in the lateral direction on account of restricted surface. This requirement makes them more adaptable to this type of balance perturbations. Furthermore, female's ability to move forward with speed was more effective towards the Right direction, compared to males. Female gymnasts therefore, as they move faster to this direction, balance their body more effectively than males.

Table 1
Description of the measured parameters.

Parameter	Description
Reaction Time (RT) (sec)	RT was defined as the time in seconds between the signal to move and the initiation of movement
COG velocity (MVL) (deg/sec)	MVL was defined as the average speed of COG movement (expressed in degrees per second) between 5% and 95% of the distance to the primary endpoint
Directional Control (DCL) (%)	DCL is a comparison of the amount of movement in the intended direction (toward the target) to the amount of extraneous movement (away from the target)
End Point Excursion (EPE) (%)	EPE was defined as the distance of the 1st movement toward the designed target, expressed as a percentage of maximum LOS distance. The endpoint is considered to be the point at which the initial movement toward the target ceases
maximum excursion (MXE) (%)	MXE is the maximum distance achieved during the trial

Table 2
Means and adjusted means in Limits of Stability Test of Reaction Time Right Forward (LOS RT RF) (sec) and Movement Velocity in Right Forward direction (LOS MVL RF) (deg/sec) for female and male gymnasts.

	Female	Male
Number of injuries	1.50 (1.08)	2.50 (0.71)
LOS RT RB (sec)	0.59 (0.19)	0.83 (0.30)
Adjusted LOS RT RB (sec)	0.56 (0.08)	0.86 (0.08)
LOS MVL RF (deg/sec)	4.76 (1.52)	3.09 (0.42)
Adjusted LOS MVL RF (deg/sec)	4.77 (0.39)	3.08 (0.39)

Table 3
Questions to the participants.

1) How long ago did you sustain a lower limb injury**?**
2) What type of injury did you sustain?
3) Where you required to stop training and if yes, for how long?
4) Where you hospitalized? and if yes, for how long?
5) When you returned to training had you fully recovered from your injury/injuries?

The results of the present study verify data of Ekdalh, Jarnl, and Andersson (1989), who found that females demonstrate better balance than males. The ability to maintain balance is dependent on visual cues, vestibular function, and somatosensory feedback from structures in the lower limb (Nashner, 1993). Impaired balance in turn and deficits in postural stability were reported for individuals with ankle injuries (McKeon & Hertel, 2008; Ryan, 1994; Wikstrom, Fournier, & McKeon, 2010). The present results extend previous data which support that not only acute musculoskeletal injury (Bonfim, Grossi, Paccola, & Barela, 2008) but also chronic musculoskeletal conditions, including ankle instability, can impair postural control (McKeon & Hertel, 2008). The musculo-tendinous changes around the ankle or the loss of proprioceptive information may contribute to the deficient postural control mechanisms after injury.

Female gymnasts may have used the ankle strategy more effectively than males which means that they may have used the ankle joint as a pivot point to move their body. The postural adjustments are controlled by the ankle muscles, restoring the Center of Mass (CoM) to a central position (Winter, Patla, & Frank, 1990). The decreased number of injuries therefore did not impair the somatosensory feedback from the ankle joint of females to the same extent compared to their male counterparts.

Certain limitations do not allow generalization of the present findings without caution. The external focus of attention for example may be a factor that differentiates female and male gymnasts (McNevin & Wulf, 2002). Researchers have reported that boys are less attentive and more agitated during the postural stability tests (Steindl, Kunz, Schrott-Fischer, & Schholt, 2006). Attention however was not recorded in the present study. Second, certain anthropometric variables affecting postural balance, such as vision (Alonso et al, 2012) were not examined. The proprioception is produced through the simultaneous action of the visual, vestibular and sensorimotor systems, and each of them has an important role to play in maintaining postural stability (Liaw, Chen, Pei, Leong, & Lau, 2009). Finally, the effect of relevant factors such as the somatotype, body size, body mass, etc (McKeon & Hertel, 2008) may have had an impact upon the postural tests. The above limitations may be useful for future consideration.

CONCLUSIONS

The present findings indicate that elite female gymnasts exhibit better postural stability scores compared to elite males, when controlling their ankle injuries. Taking into account that these injuries occurred 7 to 17 months prior to the test (M =11.20 SD = 2.65), it appears that ASI affect postural control long after acute injury recovery. However, the rehabilitation (treatment) as well as the training requirements of both female and male gymnasts may have also an impact upon their postural stability. Males for example compete only in two events where they support mainly with their feet (vaulting horse and floor exercises), compared to females who compete in three such apparatus (balance beam, vaulting horse, floor exercises). In other words, females are spending more training time using their lower limbs. Further, the balance beam, an apparatus requiring extensive balance training, is exclusively a female event and skill. The event requirements therefore may have assisted to a wider extent the female athletes to overcome their post ASI postural deficiencies examined and to exhibit better postural stabilitywhen compared to their male counterparts. It is recommended that: a) a postural stability/balance evaluation is carried out prior to the gymnast's return to training and competition, b) the gymnast is fully rehabilitated (or has fully recovered from injury) prior to his/her return to training and competition, c) the way the injury happened and the exercise that created the injury, is registered and d) the muscular strength of the injured member is registered.

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Corresponding author:

George Dallas
Chlois & Chrisoupoleos, 19002 Paiania, Athens Greece
Mobile phone: 0030 6936 592 665
Fax: +0030 210 72 76028
Email: gdallas@phed.uoa.gr

IMPACT OF GYMNASTICS PROGRAM ON HEALTH-RELATED FITNESS IN ADOLESCENT PUPILS

Nebojša Trajković[1], Dejan Madić[2], Goran Sporiš[3], Aleksandra Aleksić-Veljković[1] and Kamenka Živčić-Marković[3]

[1]Faculty of Sport and Physical Education, University of Nis, Nis, Serbia
[2]Faculty of Sport and Physical Education, University of Novi Sad, Novi Sad, Serbia
[3]Faculty of Kinesiology, University of Zagreb, Zagreb, Croatia

Original article

Abstract

The aim of this study was to determine the effects of gymnastics program in school on health related fitness in adolescent pupils. The study involved 58 adolescent pupils (14.82±0.44 years) attending the first grade at high school involved in a 12 week of gymnastics classes. The variables were selected within the battery of tests Eurofit, measuring abdominal strength, flexibility, aerobic fitness and upper and lower body strength, speed and agility. The results showed average initial level and later dynamic increase in the physical fitness of the participants. Pre-test to post-test values showed significant improvements in all tested variables (p<0.05), except for the 4x10m test. Therefore, participation in gymnastics must be recommended as a positive foundational activity for school-aged children, from early childhood to adulthood. Additionally, the results can provide useful information in optimizing the training loads of pupils involved in gymnastic training throughout Physical Education classes.

Keywords: *effects, PE classes, training, physical fitness.*

INTRODUCTION

Health-related physical fitness includes the characteristics of functional capacity and is affected by the physical activity level and other lifestyle factors. Regular participation in moderate and vigorous levels of exercise increases physical fitness, which can lead to many health benefits (Ruiz et al., 2006). Fitness, physical activity behavior and motor skill development are important components of the Physical Education (PE) curricula and are potentially indicators of child health (Lloyd, Colley, & Tremblay, 2010). Physical fitness in children and adolescents has also been linked to positive health outcomes in adults (Kvaavik, Klepp, Tell, Meyer, & Batty, 2009). Moreover, motor skills can be used for talent identification to predict sport success in children (Grice, 2003).

Gymnastics is an excellent mechanism for the teaching basic motor skills and promoting health-related fitness in children of all ages (Coelho, 2010; Donham-Foutch, 2007). Many agree that involvement in gymnastic training can contribute significantly to the all-around development of a child (Sloan, 2007) and that a physical education program including gymnastics benefits children in many areas (Werner, Williams, & Hall, 2012). Gymnastics is commonly included in PE programs across the world. It represents an activity with many benefits, to the point that it has been described as a fundamental and critical part of the PE curriculum that should be offered in preschool through faculty (Donham-Foutch, 2007). One such benefit is that it promotes abilities related to health and fitness (Werner et al., 2012; Baumgartner & Pagnano-Richardson, 2010). There are several well-known, health-related fitness batteries to assess fitness in all its dimensions in young people. A good example in Europe is the Eurofit battery (Committee of Experts on Sports Research EUROFIT, 1993).

Many authors have reported that modern artistic gymnastics requires greater strength and power because of the ever-increasing technical difficulty required through revision of the Code of Points (Jemni, Sands, Friemel, Stone & Cooke, 2006). Previous research has demonstrated the positive effects of a four-week after school programme addressing motor skills and fitness can have in young children (Matvienko & Iradge, 2009). Madić et al. (2009) conducted research on a sample of 250 girls involved in the program of gymnastics development as well as on the 580 girls who were not involved in sports. The authors applied a battery of eight motor tests, emphasizing that the research results clearly confirm that the gymnastic facilities have a positive impact on motor abilities. Delas Kalinski, Miletic & Bozanic (2011) found out that gymnastics skills learned at the age of 6.5 are retained over time after a period without any practice which makes them suitable for PE classes. Learning gymnastics skills in childhood can increase children's capacity for skill performance and improve their motor abilities. One of the major benefits of children's participation in gymnastics compared to that of untrained participants in other sports is enhanced strength (Andersson, Sward, & Thorstensson, 1988; Benke, Damsgaard, Saekmose, Jorgensen, & Klausen, 2002; Maffulli, King & Helms, 1994).

Understanding the benefits of participation in gymnastics training implemented in schools would provide relevant information for this area. It is widely known that PE classes have positive impact on the children's physical fitness. However, a great amount of researches were conducted on preadolescent children or younger because of early specialization in Gymnastics. However, establishing normative ranges for these physical tests in adolescent children will be valuable for practitioners conducting similar physical fitness testing in the future. Therefore, the aim of this research is to determine the effects of gymnastics program in school on health related fitness in adolescent pupils.

METHODS

Fifty eight adolescent pupils (14.82±0.44 age) from a High School in Leskovac, Serbia, participated in the present study. They were enrolled in Artistic gymnastics classes. All participants were male. They were informed of the nature and possible inconveniences associated with the experiment. Ethical approval was granted by the University Ethics Committee. Prior to data collection parental consent and child assent was obtained. No child had any reported history of learning difficulties or any behavioral, neurological or orthopedic problems that would qualify as exclusionary criteria for this study. Children participated in 45 minutes per session of sport gymnastics training that included activities based on fundamental movement skills. Data was collected during two sessions, before and after the eight-week gymnastics training programme in school.

Table 1
Baseline physical characteristics.

	Initial	Final	
Height (m)	175.00±6.65	177.45±6.56	p=0.220
Body Mass (kg)	68.69±11.82	66.54±10.45	p=0.938
BMI (kg·m-2)	22.05±2.57	21.46±2.34	p=0.970

The variables were selected within the battery of tests Eurofit so that the research results could later be compared with the results of other research studies carried out in Europe. The measuring instruments were either the same as or similar to, but of the same metric characteristics, those prescribed and described in the instructions for the realization of Eurofit testing.

Anthropometric variables were measured according to the guidelines of the International Biological Program. Body height was measured to the nearest 0.1 cm by a metric measuring tape. Body weight was measured to the nearest 0.01 kg using a digital scale. BMI stands for Body Mass Index. It is a measure of body composition. BMI is calculated by taking a person's weight and dividing by their height squared.

Health related physical tests

Traditional practice of testing which assessed the so-called latent dimensions of motor space (e.g., speed, strength, coordination, etc.), has been replaced by tests that assess the health-related physical fitness of children (Hastad & Lacy, 1998). First grade pupils were chosen because of certain past experience with artistic gymnastics skills and because their motor development is still in progress. Also, it is expected that their activity and inactivity outside of school would be similar.

All tests were performed at similar times in the morning on different days. At least 2 hours separated each test from the preceding meal. Diet was not controlled during the study. All subjects were instructed to have a light breakfast, and to avoid coffee and cigarettes during the testing day. They were also instructed not to engage in strenuous activity during the day before an exercise test.

The day before the test, the motor test battery was introduced to all the pupils, who did three test trials. Pupils were measured indoor, after standard warm up (5 minutes of running, and 10 minutes of dynamic stretching). They were encouraged to show maximum effort in all tests. If a subject made a procedure error during the tests, instructions and demonstrations of the task were repeated, before the child made a new attempt.

Sit and reach test (flexibility): sit and reach test apparatus was used to determine the trunk flexibility. Children were seated with the extended knees and the feet totally leaning in the seat. The subject tried to reach the largest distance slowly with the hands, without bending the legs. The measures were taken three times, with the best attempt recorded in centimeters.

Standing long jump (explosive strength): the child started with her feet in parallel behind a starting line, one shoulder width apart. After a signal the subject was allowed to swing her arms backwards and forwards and tried to jump as far as possible. The jump distance was measured in centimeters. The measures were taken two times and the highest value was recorded at the two attempts.

Vertical jump (explosive strength): the person stands side on to a wall and reaches up with the hand closest to the wall. Keeping the feet flat on the ground, the point of the fingertips is marked or recorded. This is called the standing reach. The person puts chalk on their finger-tips to mark the wall at the height of their jump. The person then stands away from the wall, and jumps vertically as high as possible using both arms and legs to assist in projecting the body upwards. Attempt to touch the wall at the highest point of the jump. The difference in distance between the standing reach height and the jump height is the score. The best of three attempts is recorded.

Sit-ups (abdominal strength and muscular endurance): A standard procedure for the 30 sec bent-knee sit-up test was applied (Semenick, 1994). The subject lay supine on a gymnastic mat with his knees bent and feet fixed on the floor 25–30 cm apart. The subject’s fingers were interlocked behind the neck, and the backs of the hands touched the mat. The sit-up was correctly completed when the elbows touched the thighs and the subject returned to the starting position until the upper portion of the back made contact with the mat. The number of sit-ups correctly completed in 30 sec became the score.

Bent arm hanging (strength and endurance): The child was hung on the uneven bar with an overhand grasp with the assistant's support. She raised her body off the floor to a position in which the chin is above the bar; elbows were flexed and chest was close to the bar. Upon a signal, stopwatch was started and the hanging time was recorded.

4x10m (test of speed and agility). Marker cones and/or lines are placed five meters apart. Start with a foot at one marker. When instructed by the timer, the subject runs to the opposite marker, turns and returns to the starting line. This is repeated four times without stopping (covering 40 meters total). At each marker both feet must fully cross the line. Result is a record of the total time taken to complete 40 m.

Push - up (strength and endurance): The subject did a push - up position on the mat with hands placed wider than the shoulders; fingers stretched out and whole body went straight on the mat. Then the subject lowered the body using the arms until the elbows bent at a 90 degree angle, and upper arms were parallel to the floor. The subject pushed up and continued in the movement until the arms were straight on each repetition. The score was the number of 90 degree push – ups performed (The Cooper Institute, 2007).

Aerobic fitness was assessed using the *20 m Shuttle Run Test* or the Beep Test; it was first described by Leger and Lambert (Leger & Lambert, 1982) and identified in a recent review as a reliable and valid field test for use among children and adolescents. (Freedson, Curetan & Heath 2000). Pupils are required to run between two lines 20 m apart (one "lap"), starting at 8.5 km/h and increasing by 0.5 km/h every two minutes, in synchrony with a cadence tape. Students were tested in groups of about 15, and the test was supervised by at least two of the field team. The number of laps completed was determined by the student failing to keep pace with the cadence tape on two consecutive laps or voluntarily withdrawing. The last completed stage or half-stage at which the participant drops out was scored.

These tests were chosen because they have been clearly defined and validated in other studies (Beurden, Barnett, Zask, Dietrich, Brooks, & Beard, 2003; Espana Romero, Artero, Jimenez-Pavon, Cuenca-Garcia, Ortega, & Castro-Piaero, 2010; Fjortoft, 2000), they are easy to administer, and time efficient, and they cover a variety of skill components.

Experimental program

The experimental program was implemented during the school year 2013-2014 in a period of twelve weeks in the high school in Leskovac. The fundamental aim of the training process was to influence the improvement of motor abilities, to help pupils to learn to implement some gymnastics elements and to prepare them for the exam of the subject. One week before the training program players performed the general conditioning in order to prevent possible injuries. None of the players was performing any additional resistance or aerobic training outside of the 2 PE gymnastics classes.

The sport gymnastics program was conducted two times a week. Each session lasted for a 45 minutes. Pupils were divided in two groups with equal number of participants. All workouts were supervised by trained artistic gymnastics instructors and a PE teacher. Both groups had the same conditions and the same instructors and teachers. Each class unit contained three training phases (Table 2): First phase started with a warm-up which included slow running and stretching and ended with a polygon with different kind of movements. This was followed by a set of gymnastic exercises. The third phase of class was focus on restoring the normal level of emotional, mental and physiological bodily functions and re-establishing the same state that the pupils were in before the beginning of the practice period. The experimental treatment included basic gymnastics skills, according to apparatus available at the moment:

Acrobatic, vault, mini trampoline, parallel bars (Table 2).

The basic learning and teaching method was the synthetic method, with the analytic method used if there was an acquisition of new motor skills. Information was presented to the pupils participating in the practice or PE lessons by means of oral presentation, motor demonstration or performance of simple motor tasks. The most commonly used methodological organizational forms of work was work in groups of 6 to 8, and frontal work. Class was divided into four groups. Pupils change their place/apparatus according to number of repetitions or when the planned time for that apparatus ends. Training impact (loads) were primarily administered on four gymnastics apparatuses (7-8 min on each): (1) acrobatics: 10-15 repetitions for roles and cartwheel ; 7-10 repetitions other skills ; (2) parallel bars : 15-20 repetitions in 3 sets for swings; 5-10 repetitions in 3 sets for dips; 8-10 repetitions for dismounts (3) Mini trampoline: 15-20 jumps; and (4) Vault: 15-20 jumps. Training load was determined according to the level of skills. In the first six weeks pupils performed easier gymnastic skills, which referred to a greater amount of repetitions. Other six weeks included more complex skills, as well as connected elements into exercise, which influenced the lower number of repetitions.

Statistical analysis

All data analyses were performed in IBM SPSS Statistics 19.0 statistical program. The Kolmogorov-Smirnov test was used to assess normal distribution of the variables. Basic descriptive statistics were calculated (mean value and standard deviation). Comparisons between baseline and the 12 week post-study testing for all performance variables were performed using a paired-samples t-test. Effect sizes (ES) were also calculated to determine the magnitude of the group differences. ES (Cohen's d) were classified as follows: <0.2 was defined as trivial, 0.2–0.6 was defined as small, 0.6–1.2 was defined as moderate, 1.2–2.0 was defined as large, and >2.0 was defined as very large (Hopkins, Marshall, Batterham, & Hanin, 2009). In additional, percent changes were determined for all variables after 12-weeks training program. In all cases, the level of significance was accepted at $p<0.05$.

RESULTS

Table 1 shows the results of the basic anthropometric characteristics of tested pupils in both trials (pre and post-) and the significance of differences between the variables.

Table 2
Training program used between weeks 1 and 12.

Goal: improvement of motor abilities and health related fitness Sessions 1–24 (Tuesday -Friday)	
Exercises	
Warm up (8-10 min)	General warm up followed by polygon with different kind of movements. Five circles were performed with 20 sec break between.
Acrobatic	Rolls, dive roll, rolls combined with other elements , cartwheel, handstand, handstand and roll forward; roll backward to handstand, forward handspring
Vault	Split and squat jump on soft mats with assistant support, straddle through
Mini trampoline	Straight jump, split jump, tucked jump, piked jump, piked split jump
Parallel bars (30-32 min)	Swing in hang and support, -dip, dip swing, - back swing dismount, back swing dismount tucked half turn with support, front swing dismount
Stretching (3-5)	5 minutes of stretching for the muscle groups mainly involved in sessions

Table 3
Results of the health related physical tests in adolescent pupils (N=58).

Test	Initial	Final	ES	Δ changes	P value
Standing long jump	173.62±28.08	186.45±26.56	0.46	7.4%	0.009
Vertical jump	41.937±8.132	47.564±7.65	0.71	13.4%	0.001
Sit-ups	20.84±3.98	26.35±4.24	1.34	26.4%	0.001
Bent arm hanging	39.23±19.31	43.56±17.23	0.24	11.0%	0.019
Push - up	20.12±10.57	24.5±9.36	0.44	21.8%	0.001
Sit and reach	7.85±8.7	10.15±7.4	0.28	29.3%	0.005
Shuttle-run	6.4±2.3	6.9±2.1	0.23	7.8%	0.025
4x10m	11.79±1.56	11.24±1.36	-0.38	-4.7%	0.998

Table 3 shows the participants' results in eight Eurofit tests. Results for the pre-test post-test values of the experimental programme showed significant improvements in all tested variables ($p<0.05$), except for the 4x10m test. There was no statistically significant difference between the two measurements with regard to speed and agility testing.

DISCUSSION

We have tested the hypothesis that 12 weeks of gymnastic PE class program would lead to significant improvements in fitness performance in healthy boys. It was observed that pupils who added gymnastic training to their PE program were able to achieve great improvements in Eurofit testing battery. The average height and mass of boys was 175.00±6.65 cm and 68.69±11.82 kg. The results were similar or better compared to the norms for body height and mass in comparison with the general population of boys in this age group founded in several researches (Lovecchio, Casolo, Invernizzi, & Eid, 2012; Vaid, Kaur, & Lehri, 2009; Lissau et al., 2004). Body mass index (BMI) in both trials was little higher than the general population norms of boys in other researches (Lissau et al., 2004). Lovecchio et al. (2012) found BMI values for 15-year-old students of 20.20±2.70 which is lower than values obtained by our research.

Table 3 shows the participants' results in the eight Eurofit tests. The results of the test measuring flexibility (sit-and-reach test) were at a very low level at baseline. Katic (1995) showed that 6-month athletic training did not significantly improve flexibility in contrast to Violan et al. (1997), 6-month karate training. In our study adolescents were exclusively submitted to lower body stretching at each session. However, as with other components of physical fitness, flexibility is a parameter that has to be emphasized specifically. Limited flexibility of hamstring in adolescents might cause low-back pain in any age groups (Rodriguez, Santonja, López-Minorro, Sáinz de Baranda, & Yuste, 2008). Our results show significant improvement in the sit and reach test after the 12 week of gymnastics PE program. Therefore, similar programs for increasing flexibility should be implemented in the classes. The test results of lower limb explosive power (standing long jump and vertical jump) showed great improvement with statistical significance $p<0.05$. The increase in explosive power noted in the present study is in accordance with previous research that also found increased lower body power in young girls with a similar protocol involving gymnastic training (Boraczyński, Boraczyński, Boraczyńska, & Michels, 2013). Gymnasts generally use their own body weight to carry out specific conditioning exercises using gymnastics apparatus. Moreover, it is considered that skill-learning itself represent specific strength conditioning, because gymnasts have to repeat the exercise while carrying their body weight in different positions, switching from one to another position, sometimes with added weights (Jemni, Sands, Friemel, Stone, & Cooke, 2006).

This gymnastic training implemented in PE classes certainly results in lower body power enhancement in adolescent pupils.

Similar level of performance at baseline (20.84±3.98) was found in the sit-ups test compared to Hungarian and Finnish adolescents as well as among Americans in the study Kaj, Németh, Tékus, & Wilhelm (2013). However, above mentioned study included younger adolescents compared to those in our study. Significant improvement was noted at post-test ($p<0.01$) following 12 weeks of PE gymnastic program. Very high performance was observed in the test of arm and shoulder muscular endurance (bent-arm hang test), showing very high progress at post-test ($p=0.01$). One of the major benefits of children's participation in gymnastics compared to that of untrained participants in other sports is enhanced strength (Halin, Germain, Buttelli, & Kapitaniak, 2002). However, general strength results for children tend to plateau and in some cases decline in late adolescence and adulthood (Hunsicker & Reiff, 1976). Therefore, it is important to provide an indispensable approach for this strength training in early childhood, late childhood and adolescence. Gymnastics participation, as well other active sport activities, plays an important role here.

The results of 20m shuttle run test were significantly higher in final measurement compared to initial ($p<0.05$). This finding is an indicator that participating in this kind of sports activities could regularly improve VO2 consumption. Similar results were found in other studies conducted on European adolescents (Ortega et al., 2008; Ortega et al., 2011). Conceptually, gymnastics is very different from running. Current understanding would suggest that energetic requirements during gymnastics are mainly anaerobic in nature because of the high intensity and short duration of competitive routines (Jemni, Sands, Friemel, Stone, & Cooke, 2006). Nonetheless, a considerable improvement in shuttle run test was recorded in our pupils following eight weeks of gymnastic program. Possible reason could be found in the fact that training sessions were shorter and intense compared to training of professional gymnasts. Moreover, the results have been supported by Hoff et al. (1999) and Millet et al. (2002), who demonstrated that even though typical strength training has minimal effects on maximal oxygen uptake, it may be possible that stronger athletes are more efficient and economical, leading to enhanced endurance capabilities as a result of performing less work for a given task.

There were no statistically significant improvements after 12 weeks of gymnastic training only in the speed agility test (4 × 10 m). Agility is very important in gymnastics because with floor routines you need to be able to change direction under control. Possible reason could be found in the fact that PE and the most gymnastics floor apparatus consists of several mats in line which is different from official floor apparatus. This fact points to the need for more in-depth analysis of the training process used by trainers with focus on the applied methods.

In studies on young elite gymnasts in three age groups, increasing age and competitive level was correlated with improved motor abilities both in regards to fitness level and coordination ability (Sawczyn, 2000; Kioumourtzoglou, Derri, Mertzanidou, & Tzetzis, 1997). Overall, the level of physical fitness of the participants improved significantly in seven of the Eurofit motor fitness tests. Our results are similar with ten weeks study conducted in children following gymnastics training which improved flexibility, explosive/static strength, muscular endurance, speed and balance parameters (Alpkaya, 2013). Although it is considered that the best period for learning gymnastic skills is at the early age because of early specialization model (Jayanthi et al, 2012), this study has shown that motor abilities can also be improved in later years using an appropriate training programme. In addition to our results is statement from Ismail, (1976) who claimed that the development of physical abilities of pupils aged 8 and over improves steadily and gradually over the years the ages 18 to 19. Sawczyn (1985) underlined the importance of physical fitness in gymnastics, showing systematically increasing differences over time between gymnasts and non-trained subjects aged 10–15 years in flexibility, speed, strength, agility and endurance tests. However, it is very hard to try to isolate the effects of gymnastics training on physical fitness. This is in line with some researchers (Beunen, Malina, & Thomis, 1999; Caine et al., 2001) who have stated that it is not currently possible to establish a cause-effect relationship between training and performance in gymnastics due to limitations in the available data, inadequate descriptions of the training processes, thus taking into account covariates such as age, body size, and physical maturity.

A limitation of this short-term study is that a control group which was involved in a regular physical exercise program in school was not included. However, having in mind that regularly classes include basketball, volleyball, handball, educational-athletic games, running and jumping, it was very difficult to explain the structure and intensity of that program. Thus, the focus of the present study was on discovering the effects of twelve weeks of gymnastic training in adolescent pupils. Also, we did not assess biological maturation before the start of the study considering the possible baseline differences in physical performance.

Twelve weeks of gymnastics training implemented in PE classes had a beneficial effect on abdominal strength, flexibility, aerobic fitness and upper and lower body strength in adolescent pupils. Therefore, participation in gymnastics must be recommended as a positive foundational activity for school-aged children, from early childhood to adulthood. Data provided from this study represent useful information because of the physical tests norms in adolescent pupils, which should be helpful for practitioners conducting similar physical function testing in the future.

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Corresponding author:

Nebojša Trajković, PhD
Faculty of Sport and Physical Education
Carnojeviceva 10a
18000 Niš
Tel: + 381 69 680 314
E-mail: nele_trajce@yahoo.com

THE IMPORTANCE OF DIFFERENT EVALUATION METHODS IN PHYSICAL EDUCATION – A CASE STUDY OF STRADDLE VAULT OVER THE BUCK

Matej Majerič, Janko Strel, Marjeta Kovač

Faculty of Sport, University of Ljubljana, Ljubljana, Slovenia

Original article

Abstract

This article presents a study of three different evaluation methods for one of the most frequently evaluated skills in physical education: straddle vault over the buck. The sample of measured subjects included 193 13-year-old boys, whose video-recorded performances were evaluated by three evaluators. We analysed the differences in the reliability, objectivity and time efficiency of three different evaluation methods. The calculation of Cronbach's alpha coefficients and analysis of the variance has been used. The analysis of reliability revealed that the combined evaluation method (alpha: 0.928) was the most reliable, the holistic method was less reliable (alpha: 0.879), and the least reliable was the analytical evaluation method (alpha: 0.833). The analysis of objectivity showed that the analytical evaluation method was the most objective (alpha: 0.854), the combined method was less objective (alpha: 0.791), and that the holistic evaluation methods were the least objective method (alpha: 0.778). The analysis of time efficiency revealed that the least time had been spent in the holistic evaluation method and much more in analytical and combined evaluation method. Analysis of the three evaluators, using three different evaluation methods showed no statistically significant differences (p=0.638) between the holistic and combined evaluation method. In contrast, statistically significant differences have been found between the holistic and analytical method (p=0.000) and combined and analytical method (p=0.000). According to the analysis, we can conclude that all three evaluation methods are appropriate for the evaluation of pupils' knowledge in physical education.

Keywords: *Physical education, gymnastics, test task, evaluation guidelines.*

INTRODUCTION

For several years, knowledge evaluation has been among the most influential and simultaneously most complex conceptual educational challenges (Colby & Witt, 2000; Hay, 2006; López-Pastor et al., 2013). Recently, experts have started to emphasize the importance of formative assessment of pupils in which the aim of evaluation is providing the subjects with qualitative feedback information about their knowledge, whilst simultaneously treating each pupil as a unique individual (Blanchard, 2009; Holcar, 2014; Georgakis, Wilson, & Evans, 2015; Leirhaug & Annerstedt, 2015).

Formative assessment is a demanding process, as the primary school teacher evaluates the knowledge of pupils according to the standards set in the curriculum. Technically speaking, in order to complete the lessons, the task of a teacher is to plan a learning process and teach selected contents in such a way that pupils can acquire them. Additionally, when seen from the aspect of modern paradigm, where pupils are a focal centrepiece, evaluation is merely a means or a guide to their knowledge. In fulfilling this task, teachers have to consider the individual particularities of each pupil. As a result, the teaching process is differentiated and individualized, aiming for pupils to recognize, understand and acquire long-lasting knowledge. This is particularly important in physical education (PE), as the acquired knowledge represents the motor literacy of pupils and as such will undoubtedly influence their sporting participation in their free time and later stages of life (Kovač, Jurak, & Strel, 2003).

In Slovenia, the physical education curriculum (Kovač, & Novak, 2006) sets the guidelines for the monitoring, evaluation and marking of pupils. Monitoring is carried out by guiding pupils from general into specific and in-depth knowledge. Evaluation is carried out by providing feedback to pupils and enabling them to develop and broaden their knowledge, whilst upgrading their general knowledge into more specific knowledge. Marking is carried out through formal appraisal of pupils' knowledge in a form of a score. Marks given should represent an encouragement for pupils to acquire further knowledge. The curriculum sets the standards for the evaluation and marking of learning goals, prescribed at the end of every three-year period. Teachers decide on the goals and contents themselves, as the curriculum provides merely a general framework, which is adjusted to the specific features of the school and lesson realization. In marking, teachers possess wide autonomy, leaving the choice of criteria to their reasoning (Kovač, & Novak, 2006; Plevnik, 2008). Teachers record the marking criteria in the annual working plan and present them to the pupils at the beginning of each academic year. One of the prescribed standards at the end of the second three-year period of primary school is also the knowledge of straddle vault over the buck, performed in a way as described in the present article. The ability of teachers to use different ways of evaluation (holistic, pondered and analytical) facilitates better precision and more objective marking of pupils' knowledge.

In physical education, motor abilities, skills and knowledge are strongly interlinked. Curriculum (Kovač, & Novak, 2006) defines motor abilities as hereditary and being responsible for the execution of movement (e.g. strength, speed, coordination, etc.). In contrast, motor abilities should not be mistaken for acquired skills and learned knowledge (e.g. standing long jump, vault over the buck, etc.).

Teachers agree that in order to evaluate the knowledge of pupils, the most appropriate way is by setting them a task, which will reflect the knowledge acquired according to certain sets standards in the curriculum. In comparison to other academic subjects, PE possesses numerous specific features, as the evaluation comprises both theoretical and practical knowledge as well as the motor abilities of pupils. Assessment of "theoretical" knowledge in PE is done in a conventional fashion consistent with other more established subjects, i.e. by examination, essay or multiple choice questions. Assessment of "practical work" is less easily done. Various practices have emerged, including the use of motor skills and fitness tests, tables of points awarded for performance in areas such as games, swimming and athletics, and the subjective assessment of teachers on matters such as game performance. Assessment of motor skills is mostly done with fitness tests (López-Pastor, 1999, 2006).

Such specifics pose a problem for setting the criteria for evaluation. According to the subject and problem in question, a focus of the study was the evaluation of motor skills in the task of straddle vault over the buck. The summary of various sources on evaluation in similar tasks (Bajec et al., 2002; Dežman & Kovač, 2002; Kovač, 2012; Kovač et al., 2002; Lorenci et al., 2002; Majerič, 2004; Premlč, 2002; Štemberger, 2003; Voglar & Kovač, 2002; Zadražnik, 2002) revealed that teachers most often set the criteria in an analytical and holistic way when making assessments.

The analyses show that in PE many teachers use so-called holistic evaluation for gymnastics, dance, and game performance (Brau-Antony & David, 2002; Estrabaud, Marigneux, & Tixier-Viricel, 2000; Lockwood & Newton, 2004; Kovač, 2012; Majerič, 2004). Teachers assess pupils' skills through observation, using their own professional expertise. The task is evaluated as an entity and is not divided into separate parts. This type of subjective assessment is undoubtedly time-efficient; however, it has several limitations, as it is usually intuitive and adjusted to the level of knowledge and social relationships of the group (Brau-Antony & David, 2002; Estrabaud, Marigneux, & Tixier-Viricel, 2000; Rutar Ilc, 2003). Professional recommendations suggest analytical assessment with the use of evaluation criteria (Newton & Bowler, 2010). For each evaluated task, teachers set precise criteria and descriptions for various parts of it. Nevertheless, some teachers are of the opinion that certain contents cannot be objectively assessed in either a holistic or analytical way (e.g. athletics); therefore, they use a special so-called combined assessment, which includes characteristics of both holistic and analytical types of evaluation (Majerič, 2004; Tomažin et al., 2001a, b, c; 2002). When using this "pondered" type of assessment, teachers consider some parts of the task to be of hierarchical value according to their role in the task. Criteria and descriptions are defined as ponders, ensuring the hierarchical structure according to the importance of each task.

It is also important for teachers to be efficient with the time of evaluation, as the administrative part should not burden them or require too much time from the teaching process. The time should namely be used for the strengthening and expanding of pupils' knowledge. It is estimated that the structured use of all three evaluation methods (holistic, combined and analytical) could also result in better time efficiency and higher quality of lesson realization.

This study has examined an evaluation of one of the most common gymnastics skills: straddle vault over the buck. Numerous authors whose research deals with the assessment of skills in PE agree that the performance of pupils needs to be evaluated with deliberation and by using diverse methods (Ávalos Ramos, Martínez Ruiz, & Merma Molina, 2014; Brau-Antony & David, 2002; Burton, 1998; Kovač, Strel, & Majerič, 2008; Newton & Bowler, 2010).

The main goal of the study was to analyse the differences between three different evaluation methods of the straddle vault over the buck in order to determine the most appropriate way for assessing primary school pupils. Therefore, the measurement characteristics of three different methods (holistic, combined, and analytical) of task evaluation were analysed. As the evaluation is only a part of the systematic teaching process, it should not take too much of the teacher's time; therefore, the time efficiency of each evaluation method has also been observed.

METHODS

The study included 222 boys enrolled in the seventh grade from 11 different Slovenian primary schools, aged 13 years (± 6 months), not exempted from PE classes due to health reasons, and whose parents had given written consent for participation in the research "The Analysis of Children's Development in Slovenia" (Strel et al., 2007). The test sample included 193 boys, whose video recordings were of sufficient quality for the evaluators to be able to assess both attempts.

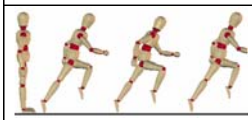
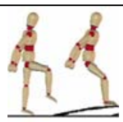
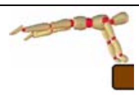
The gymnastic test task was prepared by Kovač and Čuk (2003) for the purpose of external assessment of PE in the Slovenian school system and transformed for the purpose of this study by Majerič (2004). It included a) descriptions of technically appropriate movement in separate phases of the task and b) criteria with a measurement scale and description of standards. The holistic, combined and analytical evaluation methods were used. A six-level measurement scale (0 to 5 points) was used in all three evaluation methods.

Space: Gymnasium, 18 meters × 2 meters.

Accessories: vaulting buck, 110 cm high; three mats (2 meters × 1 meter), 6 to 12 cm high; springboard, 20 to 25 cm high, 120 cm long, 60 cm wide.

Set-up: run-up distance was optional, allowing the pupils at least 12 meters from the start of the run-up to the springboard, which was placed in front of the vaulting buck at an appropriate distance, by the pupils themselves. Several mats with 6- to 12-cm thickness were placed behind the buck next to each other. The length of the mats was parallel to the axis of the apparatus and at the right angle to the run-up. A third mat was placed on top of these two mats.

Description (technique) and figure of skill straddle vault over the buck Kovač & Čuk (2003)

1) Run-up	2) Hurdle step onto the springboard	3) Take-off from the springboard	4) First flight phase	5) Approach and push-off from the vaulting buck	6) Second flight phase	7) Landing
						
Run-up length is 12 to 14 m long.	Take-off from one foot is followed by landing with two feet on the highest part of a springboard, which is marked with a line. Toes touch the line; arms are behind the body.	Take-off from both feet with arms swinging forward.	The body is extended or slightly piked. Legs straddle just before the contact of hands with the apparatus.	Hands are placed shoulder width, hips travel high above the apparatus, followed by a strong push from the hands.	The upper part of the body is elevated; legs are straddled and placed together just before the landing.	Landing in a still stand with feet together.

Description of evaluation methods

Description of the holistic evaluation method

In the holistic evaluation method, a evaluator assessed the entire presentation of a pupil without "deliberating" the (lack of) knowledge, but merely by "intuitively" forming a mark on the basis of his/her own evaluation standards (Jurman, 1989). For various marks or grades, the teacher simultaneously combined several criteria, which were more realistic according to Rutar Ilc (2003). Criteria were based on the comparison of the quality of a pupil's performance with the ideal (technically correct) model.

Each evaluator marked the first and second attempts. In each attempt, the execution werw classified according to the deviation from correct execution on a scale of 0 to 5. The correct execution were marked with the highest number of points (5) whereas no points (0) were awarded when a pupil did not perform a task or else the execution was not in accordance with the description of individual parts of the task. Attempts that deviated from correct performance were marked on a scale of 1 to 4 according to the description of the task and the expert knowledge and experience of the evaluator.

Criteria for the holistic evaluation method by Kovač & Čuk (2003)

Criteria for marking:	*Points*	Description of standards
	5	Correct execution.
	4	*Deviation from the correct execution.*
	3	*Deviation from the correct execution.*
	2	*Deviation from the correct execution.*
	1	Incorrect execution.
	0	Not executed or executed not according to the guidelines.
Marking scale:	Mark	Number of points
	1 (unsatisfactory)	0 and 1
	2 (satisfactory)	2
	3 (good)	3
	4 (very good)	4
	5 (excellent)	5

Description notes for a holistic evaluation method

The evaluator assesseed the first and second attempts at the task and noted the number of points in an appropriate field on a form. The attempt with the higher number of points was selected, transformed into a mark, and written in a final mark field. If it was necessary, the evaluator's notes was written in the appropriate field.

Pupil no.:	Attempt	Evaluator's notes	Number of points	Final mark
	1.			
	2.			

Description of the combined evaluation method

In the combined (pondered) method of assessment, a teacher evaluated pupils' attempts of the task whilst considering individual parts of the task having a hierarchical value according to their importance for the execution of the entire task. In this way, the description notes included "ponders", which were defined in a way of ensuring the hierarchical structure according to the importance for the technically correct execution of the movement in the individual task.

In this method, the evaluator assessed both attempts with points from 0 to 10. The movement in each attempt was divided into several phases, each of them with a set maximum number of available points. The evaluator assessed individual phases of movement according to the expert knowledge following the criteria, where 0 represented incorrect execution, and the highest value (ponder) in a certain phase of movement a correct execution was noted with 1, 2 or 3). The total number of points for individual phases of movement were marked down.

Criteria for the combined evaluation method adjusted to Tomažin et al. (2001a, b, c).

Criteria for evaluation of various ponders:	Value of ponder	Description of standards			
		Incorrect execution	Correct execution		
	1	0	1		
	2	0	1	2	
	3	0	1	2	3
Marking scale:	Mark	Sum of ponders (number of points achieved)			
	1 (unsatisfactory)	<3			
	2 (satisfactory)	3-4			
	3 (good)	5-6			
	4 (very good)	7-8			
	5 (excellent)	9-10			
	Final mark				

Description notes for the combined evaluation method adjusted to Tomažin et al. (2001a, b, c).

The evaluator marked points for individual phases of movement and entered the sum: the final score for each attempt onto an evaluation form. The attempt with the higher number of points was transformed into a final mark.

Pupil no.:									
Phase of movement	Highest number of available points in final score (ponder)	Attempt 1				Attempt 2			
		Incorrect execution	Correct execution			Incorrect execution	Correct execution		
1) Rhythmically coordinated run-up	-	not evaluated				not evaluated			
2) Step onto and a take-off from the springboard	2	0	1	2		0	1	2	
3) First flight phase	1	0	1			0	1		
4) Contact and take-off from apparatus	3	0	1	2	3	0	1	2	3
5) Second flight phase	2	0	1	2		0	1	2	
6) Landing	2	0	1	2		0	1	2	
TOTAL NUMBER OF POINTS									
Final mark		1 (unsatisfactory)	2 (satisfactory)	3 (good)	4 (very good)	5 (excellent)			
		<3 points	3-4 points	5-6 points	7-8 points	9-10 points			

Description of the analytical evaluation method

In the analytical method, the teacher first weighed knowledge and a lack of it and finally set a mark according to the evaluation scale and descriptions. Criteria were very precise (multi-level with a description for every level). Such an analytical approach was based on a highly precise identification of deviations (mistakes) from correct execution.

The evaluator assessed both attempts with points from 0 to 5 according to the description notes. In each attempt, the movement was divided into individual phases. Each phase contained the previously defined most common mistakes (see the column "Mistakes" in the execution of movement), which could occur in this part of the task. The evaluator assesseed individual phases according to the table provided. According to their structure, mistakes were divided in technical (deviation of technique from ideal execution) and aesthetic (deviation in elegance and poise of execution) mistakes; according to the severity of deviation, mistakes were either small or large. Small mistakes do not have a significant effect on the execution skill, but rather create a small instability in execution. Large mistakes that significantly influenced the correct execution or else prevent the pupil from performing a skill.

Criteria for analytical evaluation method by Kovač & Čuk (2003)

Measurement scale (points)	Mistakes	Description of standards
5	No or small technical or aesthetic mistakes	Autonomous and reliable execution of straddle vault over the buck without mistakes or with one small technical or aesthetic mistake.
4	Several small technical or aesthetic mistakes	Autonomous and reliable execution of straddle vault over the buck with several small technical or aesthetic mistakes.
3	Several small technical and aesthetic mistakes; one large technical or aesthetic mistakes and several small technical or aesthetic mistakes	Autonomous but not entirely reliable execution of straddle vault over the buck with several small technical and aesthetic mistakes or one large technical and several small technical or aesthetic mistakes.
2	Large technical and/or aesthetic mistakes	Autonomous but not entirely reliable execution of straddle vault over the buck with large technical and/or aesthetic mistakes.
1	Large and small technical and aesthetic mistakes	Execution of straddle vault over the buck in easier circumstances and adjusted way (sit on the buck; help of the teacher needed; fall in transition over the apparatus or landing) with large and small technical and aesthetic mistakes.
0	Not executed or not according to the instructions	Straddle vault over the buck is not performed (run by the buck, stopping in front of the buck).

Mistakes in execution of straddle vault over the buck by Kovač & Čuk (2003)			
1) Run-up		***5) Contact and push-off from the vaulting buck***	
-	Run-up is not being assessed.	TML	Low hips in transition over the buck.
2) Step on the springboard		TML	Very bent arms.
TML	Step onto the first part of springboard.	TML	Push-off is too late and weak.
TML	Step on the springboard with body leaning forward too much.	TML	Insufficient straddling of the legs and touching of buck with legs.
TML	Step on with very bent legs.	TMS	Insufficiently elevated hips.
TML	Take-off from flat feet.	TMS	Slightly bent arms.
TMS	Step on the last but not optimum part of springboard.	TMS	Hands are not parallel on the buck.
TMS	Wrong arm movement (arms upwards before the take-off).	AML	Very bent and completely relaxed legs and feet.
AML	Completely relaxed body.	AMS	Slightly bent and relaxed legs and feet.
AMS	Slightly relaxed body.	N	Fall off the buck.
N	Run by the springboard.	***6) Second flight phase***	
3) Take-off from springboard		TML	Short and low flight.
TML	Very poor execution of take-off (very bent legs in the air after take-off).	TMS	Insufficient straddle of the legs.
TML	Low take-off.	TMS	Swing with straddled legs forward.
TML	Hesitation on the springboard before take-off.	TMS	Body is not upright before landing.
TMS	Take-off is not completed (legs are slightly bent in the air after take-off).	AML	Very bent and completely relaxed legs and feet.
AML	Completely relaxed body, very bent legs and feet.	AMS	Slightly bent and relaxed legs and feet.
AMS	Slightly relaxed body, very bent legs and feet.	***7) Landing***	
N	Run and stop at the vaulting buck.	TML	Loss of balance: two or more additional steps.
4) First flight phase		TML	Landing in a deep squat.
TML	Springboard is too close to the buck, and the flight is low.	TMS	Landing with legs straight (non-elastic).
TML	Too early contact with hands on the apparatus.	TMS	Loss of balance: additional step.
TMS	Incorrect arm swing (too high or too low).	TMS	Landing outside of direction.
TMS	Too early straddling of the legs in flight.	AML	Completely relaxed body.
AML	Very bent and completely relaxed legs and feet.	AMS	Slightly bent arms; relaxed head position; relaxed body.
AMS	Slightly bent and relaxed legs and feet.	N	Fall at landing.
TMS – Technical mistake (small); TML – Technical mistake (large); AMS – Aesthetic mistake (small); AML – Aesthetic mistake (large).			

Description notes for analytical evaluation method

The evaluator totalled the mistakes and entered them in the field "sum of mistakes" for the first and second attempts, separately. The better attempt (with fewer mistakes) was marked, and points were transformed into the final mark.

Pupil no.:	Mistakes		Sum of mistakes		Final mark
			Attempt 1	Attempt 2	
	TML				
	TMS				
	AMS				
	AML				

TMS – Technical mistake (small): TML – Technical mistake (large); AMS – Aesthetic mistake (small); AML – Aesthetic mistake (large).

After warming up, six different test tasks (two gymnastics, two track and field, one basketball, and one volleyball) were explained and demonstrated to pupils who then performed each test task three times under the same conditions. The second and third attempts were video recorded; the study examines the evaluation of the gymnastics task straddle vault over the buck.

Three PE teachers evaluated the performance of tasks with a use of each protocol. For the purpose of correct evaluation, they received special training. Before the assessment, evaluators carefully read the description and the evaluation criteria of the task. Afterward, they independently evaluated both video-recorded performances in normal speed. The recordings could not be stopped, and the evaluators could not view them in slow motion or more than once. For evaluation, three different evaluation methods were used. First, the performances were evaluated with the holistic method, then with the combined method, and finally with analytical evaluation method. For each pupil, the better score of two attempts was used for further statistical analysis.

In order to monitor the reliability of the study, all three evaluators repeated the evaluation of the first ten performances at 30-day intervals. In order to examine the time efficiency of the different evaluation methods, the time needed for evaluation has been measured three times. First, time measuring was carried out for the first twenty measured subjects, then for twenty measured subjects from the middle of the sample (subjects 100–120) and finally for the last twenty subjects from the sample (subjects 203–222).

Data were processed with the use of SPSS for Windows software. Cronbach's reliability coefficient alpha and calculation of the concordance between respective evaluator's grades and the common test object were used for the evaluation of reliability and objectivity. Analysis of the variance was used to analyse the differences in scores between three evaluators. All statistics used an alpha level of $p < 0.05$.

RESULTS

Reliability of evaluation

Table 1
Reliability of evaluation – descriptive (simple) statistic parameters.

		Simple statistics – first evaluation						Simple statistics – control evaluation				
		N	min	max	M	SD		N	min	max	M	SD
HMA	E 1	10	3.00	5.00	4.00	0.47	CE1	10	3.00	4.00	3.30	0.48
	E 2	10	2.00	4.00	3.20	0.79	CE 2	10	2.00	4.00	3.10	0.88
	E 3	10	2.00	4.00	3.10	0.74	CE 3	10	2.00	4.00	3.10	0.88
	AOE	10	3.00	4.33	3.43	0.47	CA AOE	10	2.33	4.00	3.16	0.57
CMA	E 1	10	2.00	4.00	3.70	0.48	CE1	10	3.00	4.00	3.40	0.52
	E 2	10	1.00	4.00	3.00	0.82	CE 2	10	2.00	4.00	2.90	0.74
	E 3	10	3.00	5.00	3.90	0.57	CE 3	10	2.00	4.00	3.20	0.63
	AOE	10	2.67	4.00	3.53	0.45	CA AOE	10	2.33	4.00	3.16	0.50
AMA	E 1	10	2.00	3.00	2.40	0.52	CE1	10	2.00	4.00	2.50	0.71
	E 2	10	2.00	4.00	2.70	0.82	CE 2	10	2.00	4.00	2.70	0.82
	E 3	10	2.00	5.00	3.60	0.84	CE 3	10	2.00	4.00	3.30	0.82
	AOE	10	2.00	4.00	2.90	0.62	CA AOE	10	2.33	3.67	2.83	0.52

Key: HMA – holistic evaluation method, CMA – combined evaluation method, AMA – analytical evaluation method, E 1 – first evaluator, E 2 – second evaluator, E 3 – third evaluator; AOE – average of three evaluators; CA E1 - first evaluator - control (second) evaluation; CA E2 – second evaluator - control (second) evaluation; CA E3 – third evaluator - control (second) evaluation; CA AOE – average of three evaluators - control (second) evaluation.

Table 2
Reliability of evaluation– correlations between the evaluators.

		Correlation between the marks											
HMO	E 1	E1	1.000		E 2	1.000		E 3	1.000		AOE	1.000	
	E 2	CA E1	0.488	1.000	CA E2	0.933	1.000	CA E3	0.498	1.000	CA AOE	0.799	1.000
	AOE	alpha	0.655		alpha	0.962		alpha	0.659		alpha	0.879	
CMO	E 1	E 1	1.000		E2	1.000		E 3	1.000		AOE	1.000	
	E 2	CA E1	0.534	1.000	CA E2	0.922	1.000	CA E3	0.371	1.000	CA AOE	0.872	1.000
	AOE	alpha	0.695		alpha	0.956		alpha	0.539		alpha	0.928	
AMA	E 1	E 1	1.000		E 2	1.000		E 3	1.000		AOE	1.000	
	E 2	CA E1	0.304	1.000	CA E2	1.000	1.000	CA E3	0.352	1.000	CA AOE	0.725	1.000
	AOE	alpha	0.449		alpha	1.000		alpha	0.520		alpha	0.833	

Key: HMA – holistic evaluation method, CMA – combined evaluation method, AMA – analytical evaluation method, E 1 – first evaluator, E 2 – second evaluator, E 3 – third evaluator; AOE – average of three evaluators; CA E1 - first evaluator - control (second) evaluation; CA E2 – second evaluator - control (second) evaluation; CA E3 – third evaluator - control (second) evaluation; CA AOE – average of three evaluators - control (second) evaluation.

Table 3
Objectivity of evaluation – descriptive (simple) statistic parameters.

Evaluation method	Evaluator	min	Max	M	SE	SD
HMA	E 1	1.00	5.00	3.22	1.02	7.34
	E 2	1.00	5.00	2.12	1.10	7.90
	E 3	1.00	5.00	3.29	1.10	7.94
	SUM	1.00	5.00	2.88	1.20	4.98
CMA	E 1	1.00	5.00	3.18	0.90	6.46
	E 2	1.00	4.00	1.83	0.83	5.94
	E 3	1.00	5.00	3.74	0.97	6.99
	SUM	1.00	5.00	2.92	1.20	5.00
AMA	E 1	1.00	4.00	1.78	0.80	5.78
	E 2	1.00	4.00	1.77	0.83	6.00
	E 3	1.00	5.00	2.57	1.04	7.52
	SUM	1.00	5.00	2.04	0.97	4.05

Key: HMA – holistic evaluation method, CMA – combined evaluation method, AMA – analytical evaluation method, E 1 – first evaluator, E 2 – second evaluator, E 3 – third evaluator; AOE – average of three evaluators

Table 4
Objectivity of evaluation – correlation between evaluators.

		Correlation between evaluators and between the evaluators and K1				Communalities
HMA	E 1	1.000	0.613	0.586	0.888	0.788
	E 2	0.613	1.000	0.430	0.815	0.664
	E 3	0.586	0.430	1.000	0.799	0.638
	K1	λ	cum %		alpha	
		2.090	69.680		0.778	
CMA	E 1	1.000	0.639	0.568	0.880	0.774
	E 2	0.639	1.000	0.486	0.842	0.710
	E 3	0.568	0.486	1.000	0.804	0.647
	K1	λ	cum %		alpha	
		2.131	71.021		0.791	
AMA	E 1	1.000	0.834	0.559	0.903	0.815
	E 2	0.834	1.000	0.667	0.943	0.889
	E 3	0.559	0.667	1.000	0.822	0.676
	K1	λ	cum %		alpha	
		2.38	79.323		0.854	

Table 5
Time efficiency of evaluation

	HMA				CMA				AMA			
Time of evaluation	E 1	E 2	E 3	AOE	E 1	E 2	E 3	AOE	E 1	E 2	E 3	AOE
subjects 1 to 20	9.10	17.55	10.30	12.32	14.12	26.13	23.53	21.26	17.14	25.18	19.38	20.57
subjects 100 to 120	8.18	9.15	8.30	8.54	12.26	14.38	20.13	15.59	10.42	19.25	9.05	12.91
subjects 203 to 222	8.17	8.10	7.10	7.79	11.29	17.19	18.32	15.60	11.29	16.49	8.47	12.08

Key: HMA – holistic evaluation method, CMA – combined evaluation method, AMA – analytical evaluation method; E 1 – first evaluator, E 2 – second evaluator, E 3 – third evaluator; AOE – average of three evaluators; time of evaluation in minutes

Table 6
Analysis of the variance between the holistic, pondered and analytical evaluation methods.

Comparison	Type of evaluation	Simple statistics			Homogeneity variance test				Analysis of the variance	
		N	Min	max	M	SD	F	Sig.	F	Sig.
HMA/ AMA	HMA	193	1.00	5.00	2.88	0.89				
	AMA	193	1.00	4.33	2.04	0.79				
	Total	386	1.00	5.00	2.46	0.94	2.340	0.127	95.328	0.000
HMA/ CMA	HMA	193	1.00	5.00	2.88	0.89				
	CMA	193	1.00	4.67	2.92	0.76				
	Total	386	1.00	5.00	2.90	0.83	5.791	0.017	0.222	0.638
CMA/ AMA	CMA	193	1.00	4.67	2.92	0.76				
	AMA	193	1.00	4.33	2.04	0.79				
	Total	386	1.00	4.67	2.48	0.89	0.891	0.346	124.402	0.000

Key: HMA – holistic evaluation method, CMA – combined evaluation method, AMA – analytical evaluation method

Key: HMA – holistic evaluation method, CMA – combined evaluation method, AMA – analytical evaluation method, E 1 – first evaluator, E 2 – second evaluator, E 3 – third evaluator Analysis (Table 1) of the mean values of the average marks of three evaluators revealed the highest marks in the first evaluation by all three methods (HMA mean of marks in first evaluation: 3.43, mean of marks in control evaluation: 3.16; CMA mean of marks in first evaluation: 3.53, mean of marks in control evaluation: 3.16; AMA mean of marks in first evaluation: 2.90, mean of marks in control evaluation: 2.83) This has shown that all three evaluators gave lower marks in the second (control) evaluation. The analysis (Table 2) revealed that the combined evaluation method was the most reliable since Cronbach's alpha coefficient was greatest for the average mark of the three evaluators (alpha: 0.928); the holistic method was less reliable (alpha: 0.879), whilst the least reliable method was the analytical evaluation method (alpha: 0.833). Nevertheless, the Cronbach's alpha coefficient was high enough that the reliability of the evaluators was adequate in all three evaluation methods could be observed.

Objectivity of evaluation

The analysis (Table 3) showed that the third evaluator (mean values of the average marks by HMA: 3.29, CMA: 3.74, AMA: 2.57) gave the highest marks, the first a little lower (mean values of the average marks by HMA: 3.22, CMA: 3.18, AMA: 1.78) and the second the lowest (mean values of the average marks by HMA: 2.12, CMA: 1.83, AMA: 1.77). This has been typical and evident with all three evaluation methods. Compatibility between the scores of individual evaluators and the common object of assessment (the first main component of the scores of all three evaluators) was verified in order to monitor the objectivity of the evaluation. The analysis (Table 4) revealed that the analytical evaluation method was the most objective because Cronbach's alpha coefficient was the highest (alpha: 0.854); the combined method was less objective (alpha: 0.791), whilst the least objective method was the holistic evaluation methods (alpha: 0.778). Nevertheless, the Cronbach's alpha coefficient was high enough that it could be observed that the objectivity of the evaluators was adequate in all three evaluation methods.

Time efficiency of evaluation

The average evaluation time of all three evaluators revealed that the least time had been spent in the holistic evaluation method (subject 1 to 20 evaluation: 9.10 minutes, subject 100 to 120: 8.18 minutes, subject 203 to 222: 8.17 minutes). The most time has been spent in the combined evaluation method (subject 1 to 20 evaluation: 21.26

minutes, subject 100 to 120: 15.59 minutes, subject 203 to 222: 15.60 minutes). It is interesting that the combined evaluation method took more time for evaluation than the analytical method did (subject 1 to 20 evaluation: 20.57 minutes, subject 100 to 120: 12.91 minutes, subject 203 to 222: 12.08 minutes), which has been the most complex (Table 5). The analysis showed that the evaluations with all three methods were economical. Evaluators for the knowledge evaluation of 20 pupils took less than half of the school lesson time, which was defined as 45 minutes.

Analysis of differences between the holistic, pondered, and analytical evaluation methods of motor skills

The arithmetical mean value (evaluation marks) was the highest with the combined evaluation method (2.92), followed by the holistic (2.88) and analytical methods (2.04), indicating the analytical method to be the most critical. Differences in average marks between the three evaluators, using the holistic, combined, and analytical evaluation methods, have been examined with the use of analysis of the variance. No statistically significant differences (p=0.638) have been found between the marks acquired with the holistic and combined evaluation methods (see Table 6). In contrast, statistically significant differences have been found between the holistic and analytical marks (p=0.000) as well as between the combined and analytical marks (p=0.000).

DISCUSSION

School marks would be reliable if the same teachers in the re-evaluation of knowledge would give for equal marks the same knowledge (result) (Marentič Požarnik, 2000). To analyse the reliability of the evaluation in our test, all three evaluators assessed the first ten performances of the straddle vault over the buck (out of 222) twice within a 30-day interval. It has been observed that the reliability of the evaluators was adequate in all evaluation methods. The analysis (see Table 2) revealed that the combined evaluation method was the most reliable since Cronbach's alpha coefficient was greatest for the average mark of the three evaluators (0.928); the holistic method was less reliable (0.879), whilst the least reliable method was the analytical evaluation method (0.833). We have found that in our case the reliability of the evaluation was very good. For the determination of the reliability of the measurement of constructed variables the criterion by Ferligoj, Leskovšek and Kogovšek was normally used (1995). This criterion indicated the reliability of the measurement as very good, if the Cronbach's alpha coefficient was greater than or equal to 0.80, and as good if it was greater than or equal to 0.70. It has also been revealed that all three evaluators were more critical in the second (repeated) evaluation (see Table 1), indicating better insight into the perception of mistakes due to greater experience with evaluation. The extremely high reliability of the second evaluator has been observed in all three evaluation methods, in particular in the analytical method. Significantly, the lower reliability of the other two evaluators was evident, particularly in the analytical method, confirming the findings of Marentič Požarnik (2000), who stated that evaluation with the analytical method is very reliable when the criteria are well known, whilst decreases in the criteria awareness and experience also result in reduced reliability. The findings of this study are interesting, as they indicate that the holistic evaluation method is relatively reliable despite having the least defined evaluation criteria. These confirm findings regarding the measuring characteristics (Brau-Antony & David, 2002; Estrabaud, Marigneux, & Tixier-Viricel, 2000; Lockwood & Newton, 2004; Majerič, 2004), in which the authors recommended the holistic evaluation method in gymnastics. Other researchers (Bajec et al., 2002; Dežman & Kovač, 2002; Kovač, 2012; Kovač et al., 2002; Lorenci et al., 2002; Majerič, 2004; Premlč, 2002; Štemberger, 2003; Voglar & Kovač, 2002;

Zadražnik, 2002) who analysed the reliability of analytical and holistic evaluation also reported that such evaluations were reliable enough for school assessment. The values of Cronbach's alpha coefficients in these studies were according to Ferligoj et. al (1995) comparable with our results, nevertheless some researchers calculated in different test task slightly higher values of Cronbach's alpha coefficients 0.950 (Bajec et. al, 2002); 0.987 (Dežman & Kovač, 2002), 0.980 (Kovač et al., 2002); 0.970 (Lorenci et al, 2002); 0.994 (Zadražnik, 2002). We assumed that the differences in slightly higher values of Cronbach's alpha coefficients in the cited studies were due to different times that had elapsed between the first and second evaluations (a few days in these studies, 30 days in our study); different number of evaluators, motivation and special skills and expertise of evaluators (in these studies, the tasks were evaluated by specialists for individual sports; in our study physical education teachers from practice). From this point of view, our study was closer to real school practice.

The evaluation would be objective if the pupils got the same marks for the same results by different evaluators. Jurman (1989) cited various studies and concluded that Cronbach's alpha coefficients between different evaluators were between 0.70 to 0.80. He marked this values as good. In our case, regarding the objectivity of evaluation for the average evaluators' marks, the results revealed (see Table 4) the highest Cronbach's alpha coefficient in the analytical evaluation method (0.854), followed by the combined (0.791) and holistic evaluation method (0.778). Similar consistency between the evaluators was also observed by Majerič, Kovač, Dežman and Strel (2005) in an evaluation of long jump (holistic evaluation method Cronbach's alpha: 0.809; combined evaluation method Cronbach's alpha: 0.811; analytical evaluation method Cronbach's alpha: 0.836). Quite similar results have (Cronbach's alpha: 0.880) been found by Bajec, Bon, Dežman and Kovač (2002) in the analytical evaluation method test of throwing the ball to the goal in handball. Therefore, it can be concluded that with better-defined criteria PE teachers could more objectively evaluate different motor skills. From the perspective of the formative monitoring of pupils, this information is important because specifically defined criteria provide precise feedback information about their knowledge whilst simultaneously signalling to the other subjects that the mark is objective for all and thus unbiased. The subjectivity of the teacher could, therefore, be largely excluded.

In determining the time efficiency of evaluation, we considered the time spent by three different evaluators while they evaluated the pupil's knowledge by three different evaluation methods. The average evaluation time of all three evaluators revealed that the least time had been spent in the holistic method and the most time in the combined evaluation method (see Table 5). Such results were expected, as the criteria were the simplest in the holistic and most complex in the combined and analytical evaluation method. In comparison to the first timed period (subjects 1 to 20), the evaluation time to the last timed period (the last twenty subjects) was reduced in all three evaluation methods. Specifically, in the holistic and analytical evaluation methods, the time was nearly halved, whereas it was shortened by a third in the pondered (combined) method. It can be concluded that in the first batch of measured subjects (1 to 10), individual evaluators were acquiring evaluation skills for the set criteria, whereas in the second (100–120) and third (203–222) timed batches of subjects' work had already been carried out routinely. According to the data and theoretical suggestions of several authors (Airasian, 1996; Burton 1998; Rutar Ilc, 2000, 2003), it has been concluded that evaluation is predominantly organizational and thus a technical challenge, which could be carried out with higher time efficiency by providing continuous training for teachers. As the time-efficient evaluation procedures are those that with the sensible use of time and energy provide the highest quality results (possess good measuring evaluation characteristics) (Marentič Požarnik, 2000), time efficiency also needs to be considered in correlation with the reliability and objectivity of evaluation. Specifically, even the most time-efficient evaluation methods are not justified without reliability and objectivity (Kodelja, 2000). In our case, all three methods were economical. Evaluators for the knowledge evaluation of 20 pupils took less than half of the school lesson time, which was defined by 45 minutes. We did not find similar studies that would identify the time efficiency of evaluation of the test tasks.

Differences in the average marks between the three evaluators, using the holistic, combined, and analytical evaluation methods, were found between the analytical and holistic and between the analytical and combined evaluation method. In an evaluation of long jump, Majerič, Kovač, Dežman and Strel (2005) found differences in all three evaluations. We did not find other similar studies that analyse the differences between holistic, combined, and analytical evaluation methods. In our case, we have found that the arithmetical mean value was the highest with the combined evaluation method, followed by the holistic and analytical methods, indicating the analytical method to be the most critical. When comparing the values expressed in the form of school marks, the difference between the average values is a full mark, which is quite considerable. In simple terms, pupils would receive a mark of 4 (very good) for the evaluated knowledge when the holistic and combined methods are used and only a mark of 3 (good) when evaluated with the analytical method. Consequently, and considering the modern paradigm of the formative monitoring of pupils, the authors recommend that teachers in the teaching process for 13-year-old pupils to use more detailed, i.e. analytical criteria in the evaluation of knowledge. Pupils will, as a result, receive feedback information about their knowledge; they will recognize their mistakes and understand what needs to be improved. In the formal assessment, the authors recommend that teachers to use criteria in the holistic or combined methods whilst still paying conscious attention to adequate objectivity. The low marks received were a result of straddle vault over the buck being quite a demanding skill for 13-year-old pupils, particularly when performed autonomously (without the assistance of the teacher). Pupils have to connect a run-up, takeoff from a springboard from two feet and the contact/push-off with the arms from the apparatus, whereas the second flight phase has to be high and adequately long with legs straddled and straight; all movement has to finish in a stable landing. Due to the progressively lower motor abilities of pupils, which are reflected in decreased muscular strength of arms and shoulders and power strength (Strel et al., 2007), pupils could experience difficulties in the take-off from springboard and consequently with arms from the apparatus. As a result, the flight is low and short, resulting in low marks for the executed task.

CONCLUSION

Gymnastic contents are included in all PE curricula and at each level of education (Živčić Marković, Sporiš, & Čavar, 2011). In recent primary school PE curricula, gymnastics remains one of the most important elements around the world (Hardman, Murphy, Routen, & Tones, 2014), as it offers a great range of locomotive, stability and body control movements, which are highly important for the development of children (Kovač & Novak, 2001; Živčić Marković et al., 2011). Gymnastics requires a great diversity of movements: control of body movement during transitions from dynamic to static elements and vice versa, and body balance during frequent changes of the body position in space (Novak, Kovač, & Čuk, 2008; Živčić Marković et al., 2011).

Jumps and vaults are very important in the development of children. The straddle vault over the buck is one of the most common items in PE contents in all grades. Bučar et al. (2010) reported that more than 94% of PE teachers implemented this vault in the last three grades of Slovenian primary school. By including different vaults in the lessons plan, teachers will be able to improve or, at a minumum, maintain the level of motor abilities in their pupils throughout the years. Successful performance of vaults requires accurate muscular activity of specific intensity (muscular strength in arms and shoulders; explosive strength of legs during the take-off from springboard), the right moment (timing) during the take-off from the vault and flexibility (during the flight phase) and balanced landing (Novak et al., 2008).

All three evaluation methods for the straddle vault over the buck showed high reliability and objectivity evaluation, indicating the appropriate selection of test criteria and descriptions. Some differences between the three evaluation methods were not significant. Nevertheless, data for the evaluation of straddle vault over the buck revealed that the pondered evaluation method is the most reliable with regards to the measuring characteristics, whereas the analytical evaluation method is the most objective, and the holistic evaluation method the most time-efficient.

The measuring characteristics of all three evaluation methods were revealed to be appropriate; therefore, in conformity with the autonomy of teachers, it is mostly up to them to decide which evaluation method they will use as long as it is adjusted to the knowledge level of their pupils. For formative assessment, the measuring scales and criteria should be different according to the purpose of evaluation (internal, external), the developmental stage of pupils, and the complexity of the evaluated movement. As a result, the authors recommend that teachers use the analytical or combined methods in the monitoring stage of the teaching process. A prepared analytical or combined model tasks with a description of movement, common mistakes and precise criteria focuses on the learning of each pupil whilst providing suitable feedback. The process can serve as an important function in further teaching, as teachers could identify the problems of pupils and adapt the teaching process. Well-learnt gymnastics skills can generate feelings of satisfaction in pupils and encourage the practice of physical activity (Šimůnková, Novotná, & Chrudimsky, 2013). In the final formal assessment of the skill, teachers should use the most time-efficient, i.e. the holistic evaluation method, for this age group, as it will allow more time for the previous phases in the teaching process.

Teachers give the greatest importance to correct technique in gymnastics skills (Ávalos Ramos et al., 2014); therefore, the task, selected for the evaluation in the present study by three evaluators, also placed an emphasis on the technically correct execution. At the same time, Ávalos Ramos, Martínez Ruiz, and Merma Molina (2014) pointed out great contradictions in the evaluation of school gymnastics. The divergences between the use and evaluation of learning activities indicate that teachers do not employ a great deal of reflection in their planning, nor in their decision-making (Tsui, 2009). As a result, teachers need to be adequately prepared for evaluation, as the process of evaluation itself can be considered a skill (AAHPERD, 1999; Burton, 1998; Pangrazi, 1998) that can be developed in PE teachers. In order to develop this skill, continuous training in various evaluation methods has to be provided at conferences or by using various material (e.g. video recordings on the internet). Undoubtedly, quality teaching is of key importance, as only then the pupils will acquire diverse motor skills necessary for their physical and motor development.

We can confirm that the major weakness of the study was the evaluation process. The evaluators did not evaluate the knowledge of the pupils in real school situations, but the knowledge recorded on videotape. This type of evaluation was rarely used in practice. However, we found useful information from many teachers. It is important to point out that the evaluators were teachers in our study, while the evaluators were sport experts in other similar studies. From this perspective, it can be concluded, that all three evaluation methods were good tools for teachers to evaluate pupils' knowledge. Despite the reliability, objectivity and time efficiency being found in all three evaluation methods, in the future the assessment procedures in PE will need to be even more adjusted to the spirit of modern formative monitoring of pupils, encouraging the evaluation in very authentic situations. A formative assessment instrument (the assessment wheel) supports a constructivist perspective in which pupils take increasing responsibility for what is learned and how it is represented (MacPhail & Halbert, 2010). An assessment wheel is a simple form of pupil self-assessment, encouraging the pupil to record, reflect on, and map their learning to the rich task and to assess their progress towards a pre-set goal. It also identifies any learning gaps that may exists and enables pupils to plan for the next phase of their learning as well as providing a context of feedback. According to López-Pastor et al. (2013), this also signifies a move away from "test" culture to an "assessment culture" in the new paradigm of "assessment for learning".

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Corresponding author:

Matej Majerič, Ph.D.
University of Ljubljana - Faculty of sport
Gortanova 22 Ljubljana 1000
Slovenia
Tel: + 386 31 753 333
E-mail: matej.majeric@fsp.uni-lj.si

ATHLETES AND COACHES' GENDER INEQUALITY: THE CASE OF THE GYMNASTICS FEDERATION OF PORTUGAL

Maria-Raquel G. Silva[1-3], Paulo Barata[4]

[1]Scientific Commission of the Gymnastics Federation of Portugal, Lisbon, Portugal
[2]Faculty of Health Sciences, University Fernando Pessoa, Oporto, Portugal
[3]Research Centre for Anthropology and Health, University of Coimbra, Coimbra, Portugal
[4]National School of Gymnastics, Gymnastics Federation of Portugal, Lisbon, Portugal

Original article

Abstract

The aim of this study was to analyze the gender-participation among Portuguese gymnasts and Portuguese coaches, according to gymnastics' disciplines and geographical areas of Portugal. An individual-authorized data base of all national gymnasts involved in the National School of Gymnastics of the Gymnastics Federation of Portugal (Federação de Ginástica de Portugal) during three athletic seasons, namely 2012/2013, 2013/2014 and 2014/2015. Data from coaches was only available for the season of 2012/2013. In the athletic season of 2012/2013, from a sample of 14742 gymnasts, 81.2% were female and only 18.7% were male (P< 0.01). Similar results were found in the next two seasons as follows: 83.2% were female and 16.7% were male in 2013/2014 and 84.9% were female and 15.1% were male in 2014/2015. Significantly gymnasts-gender differences (P<0.01) were observed for all disciplines. In RG, WAG and MAG no differences between genders were observed due to the exclusive sport participation of female or male gymnasts, respectively. The same tendency of gymnasts' genderparticipation was observed for coaches; thus, the majority of Portuguese coaches (57.7%) was female and 42.3% were male. The inclusion of gymnastics in sport events can increase female participation due to its characteristics.

Keywords: *Gender-participation, gymnastics, disciplines, athletes, coaches.*

INTRODUCTION

Participation in sport has been linked to several physical and psychological benefitssuch as increased resistance, strength, agility, coordination and improves mood, self-esteem and self-confidence (Slater & Tiggemann, 2011). However, gender has beenconsidered a significant indicator in athletic performance's differences and gender-participation rates are different and the potential reasons are namely sports availabilityand stereotypes (Davis et al., 2006). According to the International Federation of Gymnastics (Fédération Internationale deGymnastique – FIG, 2015), Gymnastics is divided into seven disciplines as follows:Gymnastics for All (GfA), Men's Artistic Gymnastics (MAG), Women's Artistic Gymnastics (WAG), Rhythmic Gymnastics (RG), Trampoline Gymnastics (TRA), Aerobic Gymnastics (AER) and Acrobatic

Gymnastics (ACRO). Independently of the gymnastics' discipline and gymnast's gender, competitive routines Result from a combination of several different body elements that require high-intensity Effort with, in some cases, a unique dexterous manipulation of apparatus (Silva & Paiva, 2015a). Dynamic and static balance is necessary in balance positions, jumps and rotations; explosive strength is a determinant for dynamic elements with rotation and throw, jumps and pre-acrobatic movements; flexibility is dominant during all body elements; and coordination is a determinant for apparatus mastery (Calavalle et al., 2008; Silva & Paiva, 2015a).Gymnastics is an aesthetic sport that emphasizes creativity, in which athlete's peak of performance is typically obtained earlier than in team sports (Baker, Janning, Wong, Cobley, & Schorer, 2014), since gymnasts train intensively from very young ages and maintain that training regime during adolescence and early adulthood (Silva & Paiva, 2015a, 2015b). Pre-pubertal growth in children (from 2 to 10 years old) is linear and occurs at a relatively constant rate (6 cm per year) (Jeukendrup & Cronin, 2011). However, in adolescence, significant changes in body size occur, influencing physiological and physical performance (Silva & Paiva, 2015a) in both female and male gymnasts (i.e. males tend to have more fat-free mass and a lower body fat than females). In addition, leanness is also a valuable prerequisite for technical performance and is considered more aesthetically pleasing to judges and for selection at an elite level (D'Alessandro et al., 2007; Michopoulou et al., 2011; Silva & Paiva, 2015c). Coaches play an important role regarding the gymnasts' health (Schubring & Thiel, 2014). However, a reduced body mass often leads gymnasts to inadequate energy intake compromising adequate energy availability levels for gymnasts' growth, daily activities and athletic performance (Silva & Paiva, 2015a, 2015b). In spite of gymnastics being recently considered as an "early specialization" sport, characterized by a higher number of female participants than male ones (Baker et al., 2014), McManus & Armstrong (2011) highlighted that there are much less published studies in female athletes than in males. This may be due to the fact that in the short term, energy availability is required to improve gymnasts' health, to prevent injury and, in the long term, sustained low energy availability may predispose the female athletes to various health hazards such as irregular menstruation, infertility and osteoporosis (Loucks, Kiens, & Wright, 2011; Omiya et al., 2014; Silva & Paiva, 2015a, 2015c). Thus, female athletes may be a more difficult group to study, especially in relation to health issues, including body composition and menstrual function, than male athletes. On the other hand, the cultural environment and regional tradition in a typical sport also influences sport participation (Weir, Smith, Paterson, & Horton, 2010). In addition, gender is a socially category constructed in interaction between the individual and the society and self-actualization (Boykoff & Yasuoka, 2013). Therefore, this study aims to analyze the gender-participation among Portuguese gymnastics gymnasts and Portuguese coaches, according to gymnastics' disciplines and geographical areas of Portugal.

METHODS

During the sport season of 2012/2013, 1323 Portuguese coaches of gymnastics (764female and 559 male) and 15980 Portuguese gymnasts (13028 female and 2953 male) were included in this study. Also from the next two athletic seasons, 15880 gymnasts (13225 female and 2655 male) in 2013/2014 and 15469 gymnasts (13139 female and 2330 male) in 2014/2015 were included; no coaches' information was available.

Data was analyzed from an individual-authorized data base of all national gymnasts involved in the

National School of Gymnastics of the Gymnastics Federation of Portugal (Federação de Ginástica de Portugal – FGP) during three athletic seasons, namely 2012/2013, 2013/2014 and 2014/2015. Data from coaches was only available for the season of 2012/2013. This data base was constructed by technical staff of the general directorate office of the FGP and formal permission for full access of the mentioned data base was given by the director of the National School of Gymnastics of the FGP. Regarding gymnastics' disciplines, the FGP involves seven international disciplines mentioned before and two others, such as Hip Hop (HH) (organizing Open competitions and the National Championship Competition), and Teamgym (TG), a Union Européenne de Gymnastique (UEG) discipline that promotes group gymnastics competition. Thus, disciplines analyzed were as follows: GfA, MAG, WAG, RG, TRA, AER, ACRO, HH and TG. Eleven associations of gymnastics were involved in the National School of Gymnastics of the FGP and were divided into 3 main geographic areas in accordance with an equitable number of athletes: Area 1 included the North and Centre of Portugal; Area 2 included the metropolitan area of Lisbon (the capital of the country and where is located the FGP); and Area 3 represented the South of the country. Therefore, the following variables were then analyzed: gender, geographical area, involvement in gymnastics, i.e. coach or gymnast, and gymnastics discipline represented. Regarding the statistical analysis, characteristics of the participants are described with proportions for categorical variables. Spearman correlation coefficient was used to determine associations between categorical and continuous variables; due to the number of subjects evaluated the significance level used was 5% ($p<0.05$). Data was analyzed using SPSS statistical software version 22.0 for Windows (New York, USA).

RESULTS

Independently of the sport season, the gymnastics discipline most practiced in Portugal was GfA ($p<0.01$), as shown in Figure 1. This may be due to the possibility of participants of both genders being able to participate in this sport, as it is so-called "for all". In addition, GfA was followed by TRA and ACRO ($p<0.05$), with exception for the season of 2014/2015 ($p>0.05$), where more participants were involved in ACRO rather than in TRA. All others disciplines were highly less practiced as follows: RG, WAG, TG, AER, MAG and HH (Figure 1).T-tests indicate that in the athletic season of 2012/2013, from a sample of 14742 gymnasts, 81.2% were female and only 18.7% were male ($p< 0.01$). Similar results were found in the next two seasons as follows: 83.2% were female and 16.7% were male in 2013/2014 and 84.9% were female and 15.1% were male in 2014/2015. However, in RG, WAG and MAG no significant differences were observed due to the exclusive sport participation of female or male gymnasts, respectively. In an intra-athletic season analysis, a significant increase of the number of female gymnasts was shown in ACRO, RG and WAG from 2012/2013 to 2013/2014 ($p<0.05$) (Figure 2). Although not significant, only GfA and AER presented more participants in the last athletic season. However, a significant decrease of female gymnasts was observed in HH in the last athletic season ($p=0.003$) (Figure 2).

Regarding the male participation, MAG, AER and HH presented a significant increase of the number of participants ($p<0.05$) from the athletic season of 2012/2013 (Figure 3). Interestingly, GfA and ACRO have been losing participants during the last three seasons ($p<0.05$); TG also has, but not significantly ($p>0.05$).

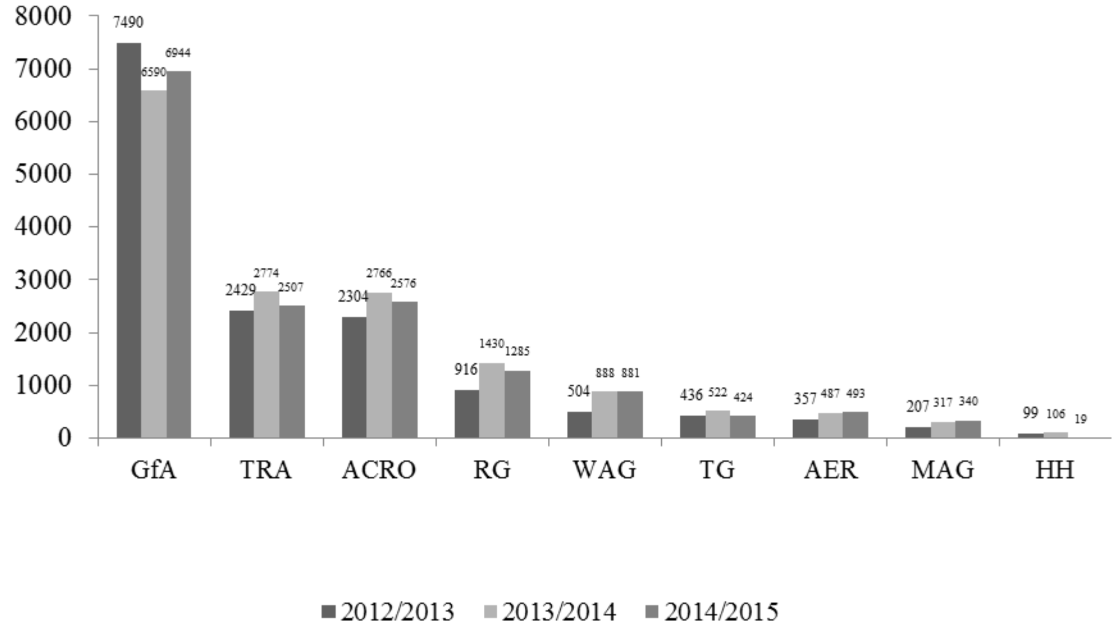

Figure 1. Number of gymnasts participating in the several disciplines of the FGP during the seasons of 2012/2013, 2013/2014 and 2014/2015 (GfA: Gymnastics for All. TRA: Trampoline Gymnastics. ACRO: Acrobatic Gymnastics. RG: Rhythmic Gymnastics. WAG: Women's Artistic Gymnastics. TG: Teamgym. AER: Aerobic Gymnastics. MAG: Men’s Artistic Gymnastics. HH: Hip Hop).

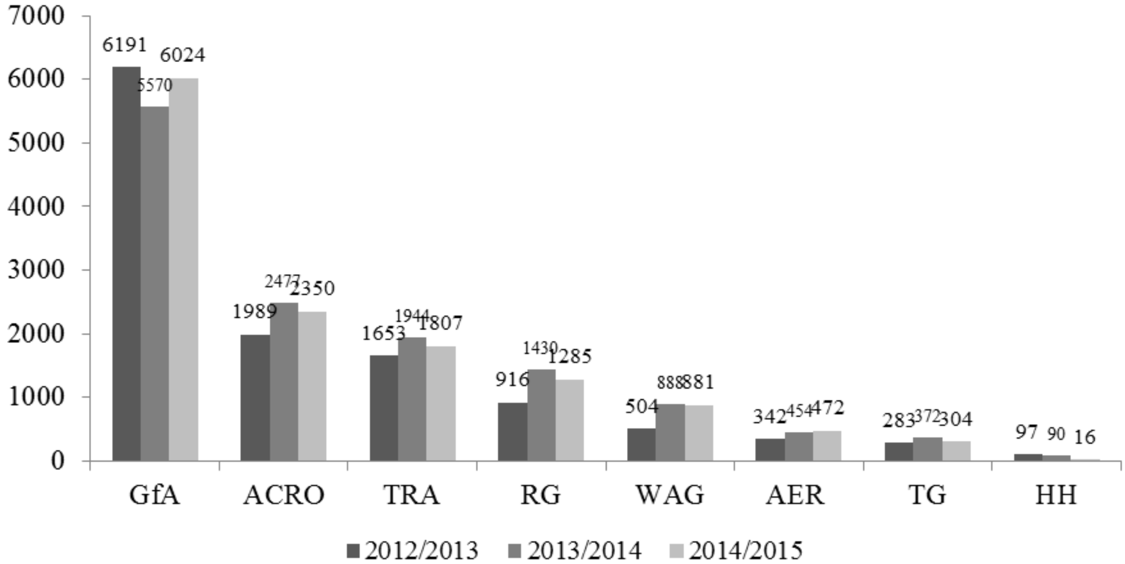

Figure 2. Number of female gymnasts participating in the several disciplines of the FGP during three athletic seasons: 2012/2013, 2013/2014 and 2014/2015 (GfA: Gymnastics for All. ACRO: Acrobatic Gymnastics. TRA: Trampoline Gymnastics. RG: Rhythmic Gymnastics. WAG: Women's Artistic Gymnastics. AER: Aerobic Gymnastics. TG: Teamgym. HH: Hip Hop).

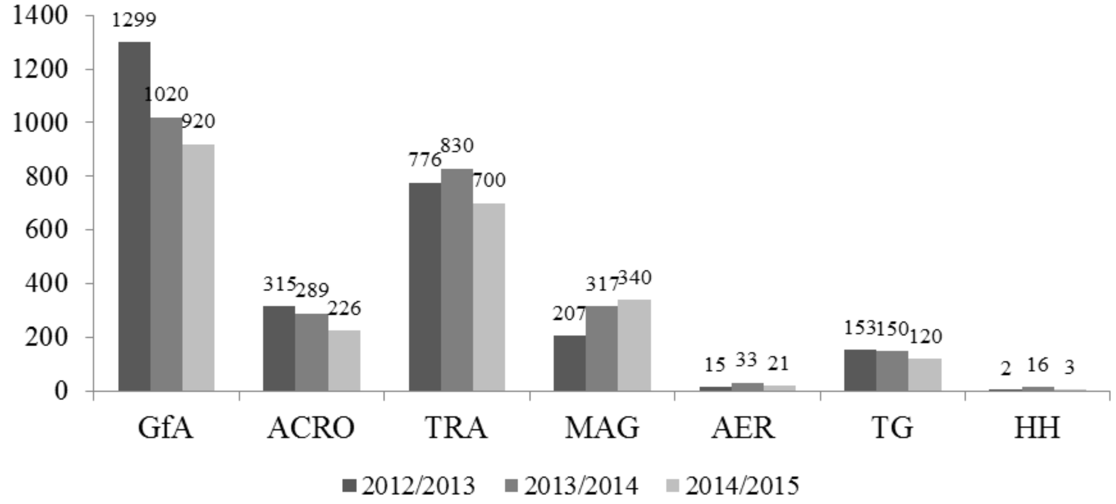

Figure 3. Number of male gymnasts participating in the several disciplines of the FGP during three athletic seasons: 2012/2013, 2013/2014 and 2014/2015 (GfA: Gymnastics for All. ACRO: Acrobatic Gymnastics. TRA: Trampoline Gymnastics. RG: Rhythmic Gymnastics. WAG: Women's Artistic Gymnastics. AER: Aerobic Gymnastics. TG: Teamgym. HH: Hip Hop).

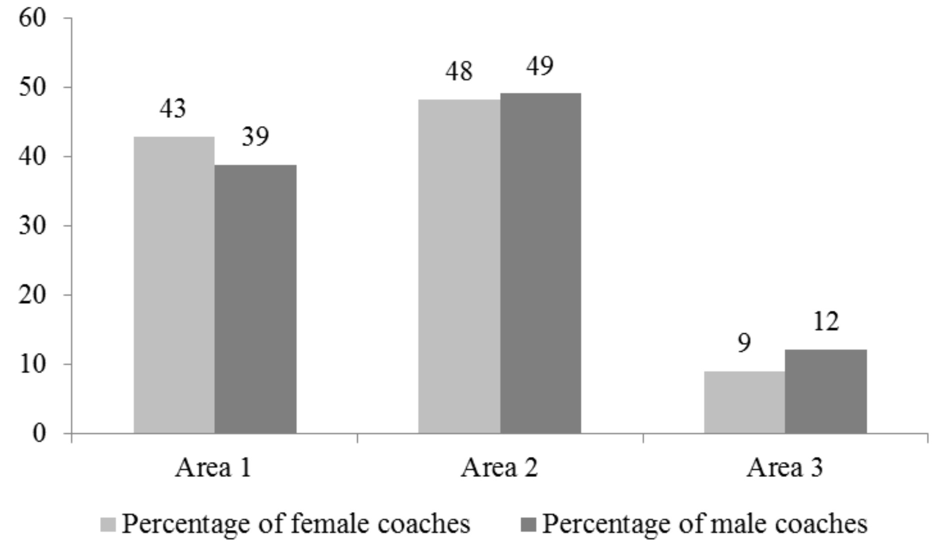

Figure 4. Percentage of female (n=764) and male coaches (n=559) during the season 2012/2013 through the 3 main geographic areas of Portugal: area 1 (North and Centre), area 2 (Lisbon) and area 3 (South of Portugal).

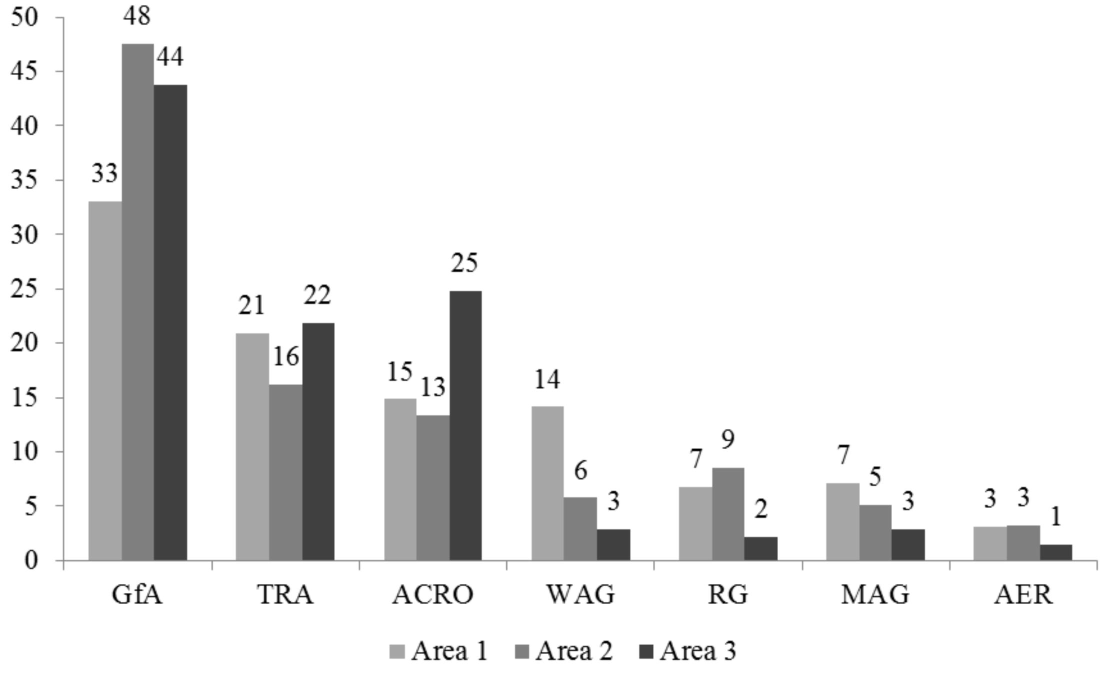

Figure 5. Percentage of Portuguese coaches working in the several disciplines of the FGP during the season 2012/2013 (GfA: Gymnastics for All. TRA: Trampoline Gymnastics. ACRO: Acrobatic Gymnastics. WAG: Women's Artistic Gymnastics. RG: Rhythmic Gymnastics. MAG: Men's Artistic Gymnastics. AER: Aerobic Gymnastics).

As mentioned before, data about Portuguese gymnastics coaches was only available for the athletic season of 2012/2013. The same tendency of gymnasts' gender-participation was observed for coaches; thus, the majority of coaches (57.7%) was female and 42.3% were male. Regarding the 3 main geographic areas, significant differences ($p < 0.01$) were observed between the first two areas and Area 3, since 48.5% of coaches (n= 642) were mainly from Area 2 (Lisbon) and 41.4% (n= 544) were from Area 1 (the North and the Centre), and only 10.4% of coaches (n= 137) worked in Area 3 (the South of Portugal). In spite of no significant differences ($p > 0.05$) were observed for gender differences, Lisbon and South areas (Areas 2 and 3) presented a higher number of male coaches than females, respectively (49.0% and 12.2% versus 48.2% and 9.0% - Figure 4). However, the opposite was observed in Area 1, where there were more female coaches (42.8%) than male ones (38.8%).

Interestingly, gymnastics disciplines with the highest number of coaches were those where participants of both genders are allowed, as follow: GfA (41%; n=545) followed by TRA (19%; n=248), ACRO (15%; n=201), with exception for AER (3%; n=40). On the other hand, disciplines of typically one gender participation presented the lowest number of coaches such as WAG (9%; n=118), RG (7.2%; n= 95) and MAG (5.7%; n=76). In a disciplines' intra-analysis with relation to the coaches' presence, there were more coaches of GfA (48%) and RG (9%) working in the metropolitan area of Lisbon (Area 2), WAG (14%) and MAG (7%) coaches were mainly teaching in Area 1, and TRA (22%) and ACRO (25%) coaches were mainly working in the South of the country, Area 3 - Figure 5).

DISCUSSION

Although several studies have been conducted in athletes, most of them are reported to males. From our knowledge, this is the first study evaluating gender-participation in both gymnasts and coaches. Significantly gender differences ($p<0.01$) were observed for all disciplines with a female participation's rate much higher than the male one. As expected, no differences between genders were observed for RG, WAG and MAG due to the exclusive sport participation of female or male gymnasts, respectively. The most practiced disciplines in Portugal were mainly those where gender selection is not a prerequisite for sport's participation, such as GfA, TRA and ACRO; this was also observed for Portuguese coaches, with exception for AER. Portuguese coaches were significantly ($p< 0.01$) concentrated in the metropolitan area of Lisbon (48.5%: 49% male and 48.2% female) and in the North of Portugal (41.4%: 42.8% female and 38.8% male, contrarily to Lisbon). The South of Portugal showed the lowest number of Portuguese coaches (10.4%: 12.2% male and 9.0% female). These results may be due to facilities allocated to clubs and respective coaches. Contrarily, competitive disciplines of typically one gender participation (WAG, RG and MAG) presented the lowest number of coaches and gymnasts. In accordance with Barker, Barker-Ruchti, Wals & Tinning (2014) and Silva & Paiva (2015b), most athletes choose to persist with competitive sport voluntarily, so may be more specialized coaches of WAG, RG and MAG should be necessary in the near future. A new challenge stands up for the sport worldwide, which is that there is a clearly inequality of gender-participation in gymnastics, since both Portuguese female gymnasts and coaches presented a high and significant presence in the Portuguese Gymnastics ($p<0.05$). This should be interpreted as part of a solution for the so called "gender inequality in sport", according to recent literature (Baker et al., 2014; Claringbould, Knoppers & Jacobs, 2015; Di Cagno et al., 2009; Godoy-Pressland &Griggs, 2014; Mackintosh et al., 2014). A plausible explanation might be related to the dominant gender in the social system around that sport, i.e. female sport produces a different environment governed by distinct social and developmental factors than those important in male sport (Barkeret al.,2014). Weir, Smith, Paterson, & Horton (2010) in a study about the age of sport participation concluded that the number of sport participants may vary due to cultural importance of different sports with the most capable athletes, the relative older ones going to sports with the greatest cultural relevance. Jacques Rogge (2012), the former president of the International Olympic Committee (IOC), highlighted at the Games Opening Ceremony that "For the first time in Olympic history, all the participating teams will have had female athletes, and this is a major boost for gender equality". In a gender equality audit about the London 2012 Olympics, Donnelly and Donnelly (2013) reported that 4835 female athletes participated in the 2012 London Olympic Games, no countries excluded female athletes and women competed in every sport. In contrast, in the London 2012 Olympics, there were 39 men-only events, including the pommel horse and rings in gymnastics, and only two women-only events, such as RG and synchronized swimming (Boykoff & Yasuoka, 2013).

One of the 'Fundamental Principles of Olympism' is that "Any form of discrimination with regard to a country or a person on grounds of race, religion, politics, gender or otherwise is incompatible with belonging to the Olympic Movement" (IOC, 2011). In addition to physical and cognitive demands, gymnasts should also integrate a high degree of technical (Barker et al., 2014) and artistic skills into their dynamic and aesthetic exercises (Di Cagno et al., 2009). On the other hand, gymnastics is known to be the oldest sport ever practiced and is often sought to be the better sport to develop physical and mentally the "raw material" in very young ages (Bakeretal.,2014; Silva &

Paiva, 2015a). Although not significantly, Portuguese female gymnasts' participation only increased in GfA and AER in the last athletic season, and the same was demonstrated by male participants in WAG. Considering that when gymnasts are relatively older, they transfer to other sports (Barker et al, 2014) and that a combination of factors might be responsible for that (Omiya et al., 2014), a problem stands up for the FGP. Age was not available for this study, but it might have a major influence in sport-participation. Education sessions to increase future gymnasts' and coaches' participation should be implemented as a new perspective of increasing both female and male participation in geographical areas with fewer participants. The limitations of this study should be taken into account when interpreting these results. First, age was not a studied variable, as mentioned before. Although its relative effects have been studied (Schorer, Cobley, Büsch, Bräutigam, & Baker, 2009), we assumed that gymnastics' disciplines would be of greater interest for this publication. Longitudinal studies are going to be implemented in the FGP in order to study the possible relation between the prevalence of a specific gymnastics' discipline according to the geographic area and gymnasts' results in national and international competitions. They would be also interesting and necessary in evaluating gymnastics' evolution in relation to gender, relative age effects and sport participation. These results shed additional light on the cultural and geographical influence for sport participation of both gymnasts and coaches. The present study provides a new insight to reinforce the practice of gymnastics worldwide, in accordance with significant differences shown by our results in relation to female and male's participation. Therefore, gymnastics should be seen as a sport that promotes greater female participation; thus, it should be used as a new strategy to combat inequality in female participation. For those interested in reducing or eliminating gender inequality in Sport and working in the governance of federations or clubs, the inclusion of gymnastics in sport events can increase female participation due to its characteristics.

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Corresponding author:

Maria-Raquel G. Silva
Rua Carlos da Maia, 296
4200-150 Oporto
PORTUGAL
Tel: +351 22 5074630
Fax: +351 225074637
E-mail: raquel@ufp.edu.pt

SHORT HISTORICAL NOTES VI

Anton Gajdoš, Bratislava, Slovakia

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

MEN TEAM USA 1964

Despite Men team USA 1964 did not took any medals at the World Championship or Olympic Games, it was important moment for USA gymnastics to attend competitions in preparations for ongoing generations. Many members of the team later became coaches, with extraordinary gymnasts and were probably reason of excellent USA gymnasts results 15 years later. It was also in political sense important to have contacts between communist east and democratic west via sport. At Olympic Games in Tokyo 1964 USA team took 7th place and their best gymnast was Makato Sakamoto who was 20th in all around. From left to right are: Tom Maloney (team manager), Makato Sakamoto, Armando Vega, Gregor Weis, Ronald Barack, Rusty Mitchell, Arthur Shurlock, Larry Banner, John Muir (coach).

LADISLAV VACHA (CZE, ex **TCH)**

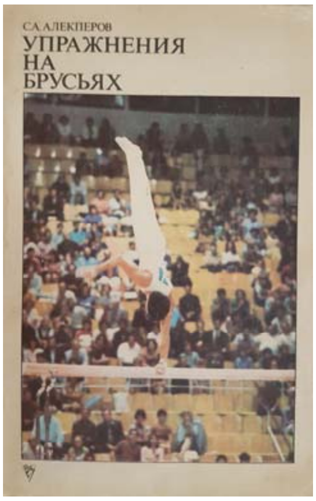
Ladislav Vácha (born March 21, 1899 in Brno – died June 28, 1943in Zlin). Ladislav's the first major international competition was 1924 Summer Olympics in Paris. At 1924 OG gymnasts competed for the last time also in rope climbing. Gymnasts have to climb on 8 meters long rope and with diameter of 28 mm and time measured automatically by electric stopwatch. Those who were climbing more than 12 seconds recived 0 points and those who were faster than 9 second received 10 points for all around result. The best in rope climbing was Šupčik (TCH) with result of 7 1/5 second, Ladislav was third with result 7 4/5 second. In Paris Ladislav took also bronze medal on rings. At next OG 1928 in Amsterdam received a gold medal in parallel bars, and silver medals in rings and team exercises. At World Championship in Lyon 1926 he was the third in all around and four years later in Luxemburg he was the fifth.

On bellow photo is one example of Ladislav vault over long horse. Despite the precise date of photo is not clear (it is from year 1928 in preparation in Praque for Olympic Games in Amsterdam), it is very informative how our sport look like. Performance is outdoor training session with spectators. Instead of mats, landing is on sands. Horse height is at coaches (Miroslav Klinger, also very famous Czech gymnast and coach) height (we can asume it is about 1,6 meter), springboard is much higher than it is nowdays, with leaf steal springs. Hecht vault as Ladislav show on photo is in terms of modern gymnastics historical vault as nobody performs it anymore.

SERGEJ ANATOLIJEVIČ ALEKPEROV

Professor Alekperov (born on 6th January, 1925, Baku; died 3rd December, 2011, St. Petersburg) belonged to the top Soviet Union and Russia gymnasts, trainers, judges and gymnastics experts. He was member of Soviet Union Army and in 1948 he won 3rd place in all around at Championships of armed forces of Soviet Union. He was the first that finished composition at parallel bars with a salto backward straight in 1948 at Soviet Union Championships in Moscow. People used to say he is „the teacher from God". He prepared and trained 28 masters of sport (highest level of athletes in Soviet Union) From 1st September, 1975 until 1993 he was the director of Gymnastics department of the Pyotr Leshaft State Order of Lenin and Order of the Red Banner Academy of Physical training St. Petersburg. He wrote more than 110 publications, books, articles where he was engaged about techniques and methodic of gymnastics. His most important book was Parallel bars exercises and had 3 editions, and was translated into Japanese language. His Ph.D. students were among others Ľudmila Turiščeva, Vladimír Aksenov, Vjačeslav Mironov and me Anton Gajdoš.

Many years he was devoted to complex research work for preparing soviet gymnasts for Championships, Olympic Games. Together with his leadership many movies were prepared about techniques and methodic of complex exercises, kinograms which helped and still help to improve preparation, training of gymnasts not only in Russia but also around the world. Bellow is Professor Alekperov photo, front page of his most important book from 1976 Exercises on parallel bars (Upražnenia na brusjah) and front page of last edition, where it was part of J. Gaverdovskij's book Artistic Gymnastics all around – men disciplines from 1987. Materials were prepared with help of prof. Raisa Terechiny.



Slovenski izvlečki / Slovene Abstracts

Sunčica Delaš Kalinski, Almir Atiković, Igor Jelaska, Mirjana Milić

ANALIZA USPEŠNOSTI TELOVADK NA PRESKOKU NA VELIKIH TEKMOVANJIH OD 2008 DO 2015

Preskok je disciplina, ki se nekoliko razlikuje od ostalih disciplin ženske orodne telovadbe glede na način ocenjevanja, trajanje tekmovalnega nastopa in gibalnih sposobnostih pomebnih za uspešen nastop. Temu primerno je tudi število telovadk, ki sodelujejo na preskoku v predtekmovanju. Na velikih tekmovanjih v obdobju od 2008 do 2015, kjer je bilo izvedeno finale v mnogoboju in na posameznih orodjih je sodeloval visok odstotek telovadk (SP2009=81,03% in SP2013=90,90%) Na ostalih tekmovanjih (OI 2008, 2012, kvalifikacije za OI 2012, SP 2014, 2015) je sodelovalo le okoli 20% najboljših telovadk v predtekmovanju na preskoku. Na osnovi vseh rezultatov velikih tekmovanj je bila narejena ANOVA in ugotovljeno je bilo, da na odločitev za tekmovanje v predtekmovanje na preskoku vplivajo gibalne sposobnosti telovadk, njihovo znanje in taktika. Rezultati lahko služijo trenerjem pri načrtovanju vadbe na preskoku.

Ključne besede: ženska orodna telovadba, preskok, razvoj.

Christoph Schärer, Klaus Hübner

NAPOVEDOVANJE NATANČNOSTI NAJVEČJEGA UPORA PRI PET DO SEDEM SEKUNDAH DRŽE IZ TESTA TREH SEKUND NAJVEČJE IZOMETRIČNE SILE PRI RAZPORI, RAZOVKI V OPORI IN RAZOVKI VODORAVNO

Na krogih se zahteva visoka stopnja relativne največje sile, da lahko telovadec v sestavi izvede do sedem prvin moči s primerno kakovostjo izvedbe. Vaditelji pri razvoju največje sile podaljšujejo trajanje drže s trenažerjem s protiutežjo oziroma obtežilnim pasom. Namen študije je bil ugotoviti ali lahko napovedujemo največji upor (MR)(najmanjšo protiutež/največjo dodatno obtežitev) pri petih ali sedmih sekundah trajanja drže ob upoštevanju kriterija MR trajanja 3 sekund pri razpori, razovki v opori in razovki vodoravno ter pripraviti vaditeljem primerno tabelo obremenitve. Deset članov švicarske reprezentance je izvedlo MR test pri 3, 5, 7 sekundah pri vseh prvinah. Rezultati so pokazali, da se s povečanjem trajanja drže, zmanjšuje MR. Povezanost med testi in linearna regresija je bila izjemno visoka (R^2>0.88) in skoraj linearna, zato so bile pripravljene ustrezne tabele.

Ključne besede: moški, orodna telovadba, sila, razovka, razpora, razovka vodoravno.

Muhamed Tabaković, Almir Atiković, Elvir Kazazović, Senad Turković

UČINEK IZOKINETIČNE VADBE NA JAKOST MIŠIC KOLENA IN USPEŠNOST IZVEDBE AKROBATSKIH PRVIN

Namen raziskave je bil ugotoviti ali dodatna izokinetična vadba vpliva na jakost mišic kolena in kako to vpliva na kvaliteto izvedbe akrobatskih prvin. Izokinetična vadba je potekala na napravi Biodex 3 (60°·s–1). V raziskavi je sodelovalo (N = 80) študentov Fakultete za šport in telesno vzgojo (starost, 19.8 ± 1.7 let; masa, 75.2 ± 2,9 kg; višina 179.7 ± 6.4 cm). Kontrolna skupina (N = 40) je med začetkom in koncem poskusa izvjala le običajno vadbo akrobatskih prvin. Poskusna skupina (N = 40) je poleg običajne vadbe akrobatskih prvin izvajala tudi izokinetično vadbo. Poskusna skupina je močno izboljšala največjo silo (tudi navor, delo in moč) upogibalk in iztegovalk kolena. Povečana jakost mišič kolena je pomebno izboljšala izvedbo akrobatskih prvin: preval letno, premet nazaj, salto naprej skrčeno in salto nazaj skrčeno.

Ključne besede: izokinetika, največji navor, moč, delo, akrobatske prvine.

George Dallas, Kostas Dallas

VPLIV POŠKODBE GLEŽNJA NA RAVNOTEŽJE PRI TELOVADCIH IN TELOVADKAH

Orodna telovadba je šport, jer je vedno prisotna nevarnost telesne poškodbe. Poškodba telovadca, naključna ali dolgotrajna je boleč slučajen poseg v telovadčev razvoj. Poškodbe imajo pomemben negativen vpliv na telovadčevo ravnotežje, še posebej pa poškodbe nog. Namen raziskave je bil ugotoviti kako poškodbe gležnja v preteklosti na eni ali obeh nogah vplivajo na ohranjanje ravnotežja. Deset telovadk (starost= 16.66 ± 3.20 let, masa = 47.30 ± 8.00 kg, višina = 158.00 ± 5.75 cm)in deset telovadcev (starost = 22.30 ± 1.77 let, masa = 62.00 ± 3.33 kg, višina = 168.50 ± 3.03 cm) je sodelovalo v presečni študiji. Sodelujočim so bile izmerjene meje stabilnosti (reakcijski čas, hitrost gibanja težišča telesa, smer gibanja telesa, skrajna točka ohranjanja ravnotežja, največja pot gibanja težišča telesa) in izračunan je bil vpliv poškodbe na ravnotežje merjen z Equitest Computerized Dynamic Posturography sistemom. Rezultati so pokazali, da imajo ženske manj poškodb, in imajo boljše reakcijske čase ter višjo hitrost gibanja težišča telesa kot moški. Večje število poškodb gležnja vpliva na spremembe v mišično vezivnem sistemu okoli gležnja in zmanjšano proprioreceptivno zaznavanje ter privede do pomanjkanja mehanizmov za ohranjanje ravnotežja. To velja tudi za samo enkratno poškodbo gležnja.

Ključne besede: meje stabilnosti, reakcijski časskrajna točka ohranjanja ravnotežja, največja pot gibanja težišča telesa.

Nebojša Trajković, Dejan Madić, Goran Sporiš, Aleksandra Aleksić-Veljković, Kamenka Živčić-Marković

VPLIV ORODNE TELOVADBE NA ZDRAVJE IN PRIPRAVLJENOST MLADOSTNIKOV

Cilj raziskave je bil ugotoviti učinke programa orodne telovadbe v srednji šoli na zdravje in telesno pripravljenost mladostnikov. V raziskavi je sodelovalo 58 mladostnikov učencev (starih 14,82 ± 0,44 let), ki so obiskovali prvi razred srednje šole. Poskus z vadbo orodne telovadbe je trajal 12 tednov. Izmerjene so bile vrednosti spremenljivke testov sklopa EUROFIT, moč, gibljivost, aerobna vzdržljivost in moč rok in nog, hitrost in okretnost. Rezultati so pokazali povprečno začetno raven in kasneje dinamično povečanje telesne pripravljenosti udeležencev. Analiza pred in po vadbi je pokazala pomembno izboljšanje v vseh testiranih spremenljivk (p <0,05), razen za 4x10m. Zato je treba sodelovanje pri orodni telovadbi priporočati kot pozitivno temeljno dejavnost za šolske otroke, od zgodnjega otroštva do odraslosti.

Ključne besede: telovadba, telesna vzgoja, vadba, telesna pripravljenost.

Matej Majerič, Janko Strel, Marjeta Kovač

POMEMBNOST RAZLIČNIH METOD OCENJEVANJA PRI ŠPORTNI VZGOJI – ŠTUDIJA PRIMERA PRESKOKA ČEZ KOZO

Raziskava predstavlja študijo treh različnih metod vrednotenja za eno izmed najpogosteje ovrednotenih spretnosti na področju telesne vzgoje: raznožko čez kozo. V vzorec merjencev je bilo vključenih 193 trinajst letnih dečkovs, katerih video posnete preskoke so ocenili trije ocenjevalci. Analizirali smo razlike v zanesljivosti, objektivnosti in časovno učinkovitost v treh različnih metod vrednotenja. Cronbachova analiza zanesljivosti je pokazala, da je kombinirana metoda vrednotenja (alfa: 0,928) je najbolj zanesljiva, celovit način je manj zanesljiv (alfa: 0,879), in najmanj zanesljiva metoda je bila analitična ocena (alfa: 0.833). Analiza objektivnosti je pokazala, da je bila metoda analitičnega vrednotenja najbolj objektivna (alfa: 0,854), kombinirana metoda manj objektivna (alfa: 0,791), in da je bile celovita metode vrednotenja, najmanj objektivna metoda (alfa: 0,778). Analiza časovne učinkovitosti je razkrila, da je bilo najmanj časa za analizo potrebno pri metodi celostnega ocenjevanja, veliko več v analitični in kombinirane metode ocenjevanja. Analiza treh ocenjevalcev, z uporabo treh različnih metod vrednotenja ni pokazala statistično pomembne razlike (p = 0,638) med celostno in kombinirano metodo ocenjevanja. V nasprotju s tem pa so bili razlike med celostno in analitično metodo (p = 0,000) in kombinirano metodo ter analitsko metodo (p = 0,000) statistično pomembne. Glede na analizo, lahko sklepamo, da so vse tri metode vrednotenja primeren za ocenjevanje znanja učencev pri športni vzgoji.

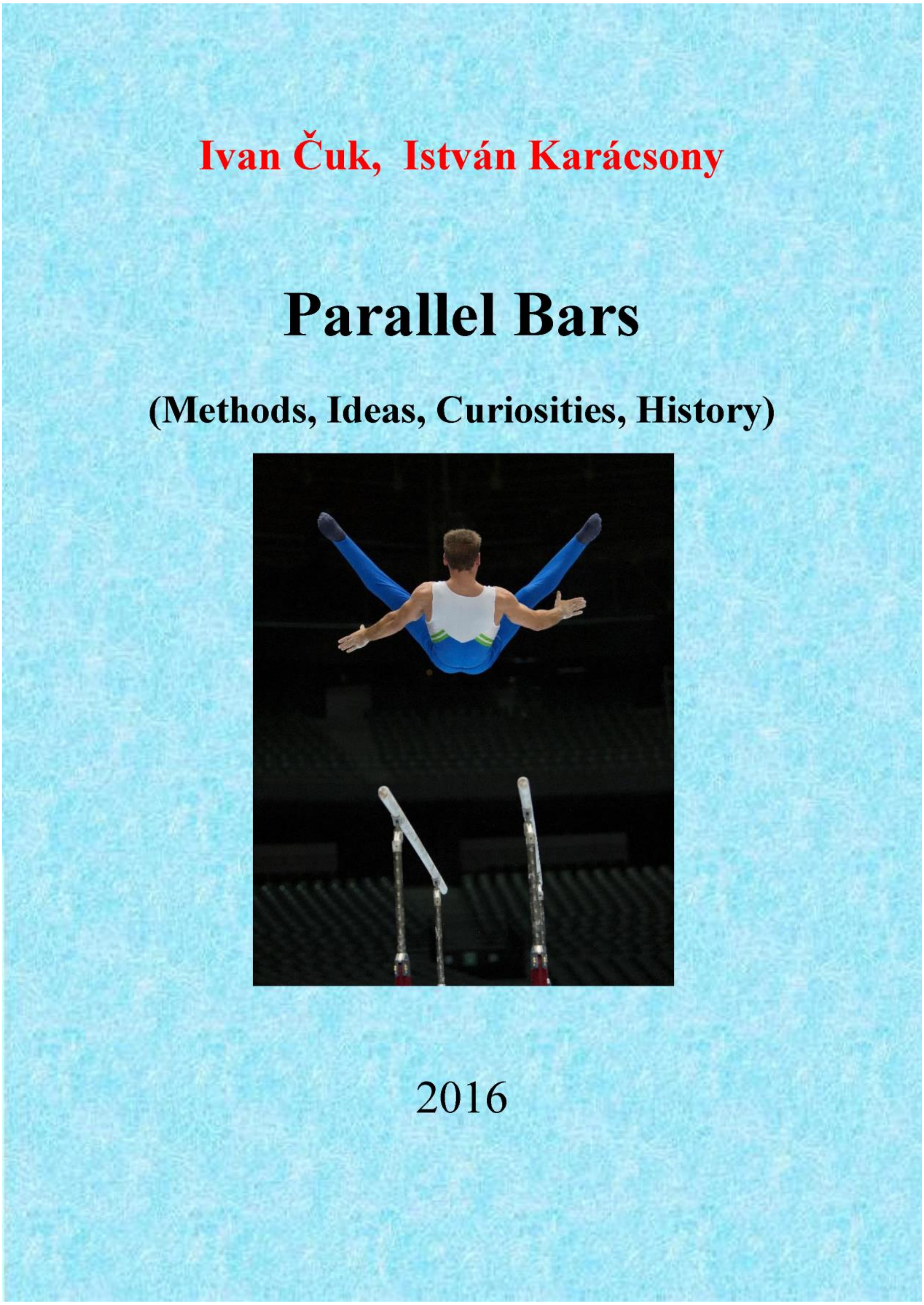
Ključne besede: telesna vzgoja, orodna telovadba, merski postopki, znanje, smernice.

Maria-Raquel G. Silva, Paulo Barata

NEENAKOST MED SPOLOMA PRI TELOVADCIH IN VADITELJIH: PRIMER GIMNASTIČNE ZVEZE PORTUGALSKE

Cilj te raziskave je bil analizirati vključenost spolov med telovadci in vaditelji, po panogah telovadbe in geografskih območjih Portugalske. Analizirana je bila podatkovna zbirka vseh telovadcev vključenih v nacionalne šole telovadbe v treh športnih sezonah, in sicer 2012/2013, 2013/2014 in 2014/2015. Podatki za vaditelje so bili na voljo samo za sezono 2012/2013. V sezoni 2012/2013 je bilo 14742 telovadcev, od tega 81,2% žensk in le 18,7% moških ($p < 0,01$). Podobni rezultati so bili na voljo v naslednjih dveh sezonah, kot sledi: 83,2% žensk in 16,7% moških v sezoni 2013/2014 in 84,9% žensk in 15,1% moških v sezoni 2014/2015. Pri vseh panogah so značilne razlike med spoloma ($p < 0,01$). V ritmiki, ženski orodni telovadbi in moški orodni telovadbi ni razlik zaradi izključno sodelovanja žensk ali moških telovadci, enako velja za vaditelje. Tako je bila večina portugalskih trenerjev 57,7% žensk in 42,3% moških.

Ključne besede: spol, udeležba, telovadba, panoge, športniki, trenerji.



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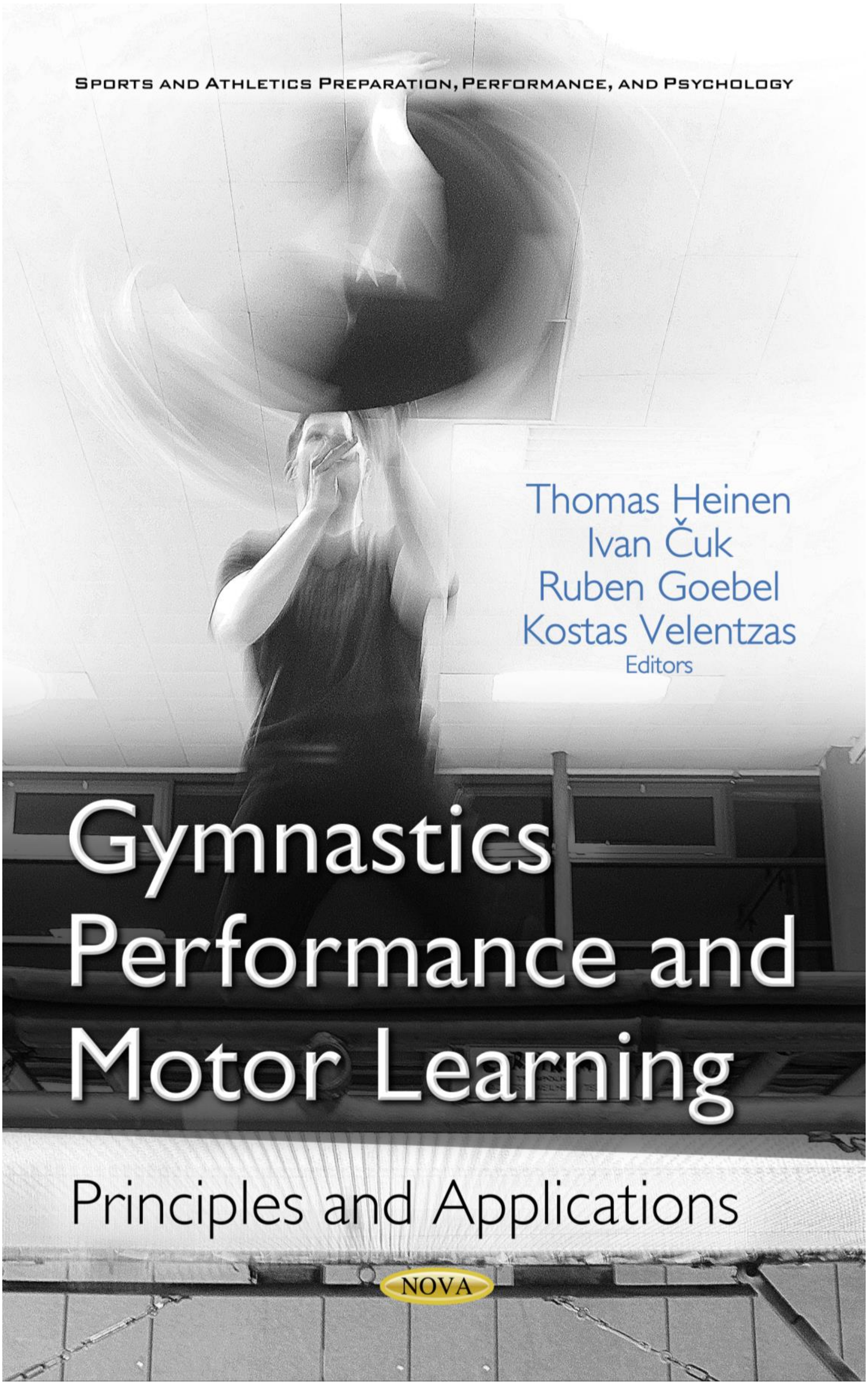
SPORTS AND ATHLETICS PREPARATION, PERFORMANCE, AND PSYCHOLOGY
Thomas Heinen
Ivan Čuk
Ruben Goebel
Kostas Velentzas
Editors
Gymnastics Performance and Motor Learning
Principles and Applications
NOVA

Gymnastics Performance and Motor Learning: Principles and Applications

Editors: Thomas Heinen (University of Hildesheim, Germany), Ivan Čuk (University of Ljubljana, Slovenia), Ruben Goebel (Qatar University, Qatar), Kostas Velentzas (Bielefeld University, Germany)

Book Description:

The book *Gymnastics Performance and Motor Learning: Principles and Applications* is a state-of-the-art discussion forum for topics that are of high interest in the field of gymnastics. Experts from different countries and with different scientific backgrounds such as psychology, pedagogy, training science, sports science, and movement science provide a number of significant contributions covering recent theoretical developments, current research evidence, as well as implications for practical applications concerning the different gymnastics disciplines. Topics discussed in the book include gymnasts gaze behavior in complex skills, spotting and guiding techniques, observational learning, augmented feedback, imagery, mental rotation, directional tendencies, interpersonal coordination, lost skill syndrome, performance indicators, as well as apparatus developments. Given the wide range of topics, *Gymnastics Performance and Motor Learning: Principles and Applications* may be an important source of information for graduate students, researchers, and practitioners (coaches and gymnasts) who work in the field of gymnastics. (Imprint: Nova)

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