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Science of Gymnastics Journal (ScGYM®)

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

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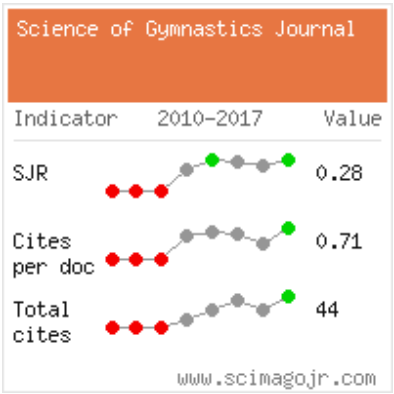

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CONTENTS

On 12th November 2018, Dolenjska Museum in Novo mesto opened exhibition on Leon Štukelj. (Photo Ivan Čuk)

Entrance hall is dedicate to Leon as an artist's inspiration, there are 14 Leon's monuments across Slovenia, besides numerous drawings and paintings. (Photo Ivan Čuk)

EDITORIAL

Dear friends,

In this issue, we have ten articles with authors from Brazil, New Zealand, Australia, Sweden, Germany, the Republic of Korea, Portugal, the Czech Republic, Spain, Greece, Tunisia and Chile. The articles cover psychology, sport training, anthropometric characteristics, motor learning, kinesiology, and biomechanics. Among gymnastics disciplines, most are dealing with the man and the women artistic gymnastics, but we also have an article on the rhythmic, acrobatic and the general gymnastics.

Our last issue had the Olympic Games as its theme. If there is interest among researchers, we would be open to preparing another special issue on a theme e.g. motor control in gymnastics, motor learning in gymnastics, etc.

Anton Gajdoš prepared another article related to the history of gymnastics, refreshing our knowledge of 100 years since the Czechoslovakian Gymnastics Federation was established.

Last year was special as we published a record number of articles, 34 in total. After evaluation, some articles were unfortunately rejected, mostly due to their non-gymnastics content and, in a few cases, extremely poor language. However, last year our journal saw an improvement in the h-index: in SCOPUS it is 7 and in WoS 4. As we haven't been present in WoS for long, it will take some time to gain the same h-index in both. If we manage to publish more than 25 articles by October, we will fulfil the criteria in PUBMED to have 50 articles in a two year-span and will start the evaluation process to be included in the PUBMED.

We need to emphasis diligent work of reviewers and give them credit to have quality articles. All reviewers in year 2018 are listed.

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

One part is dedicate to Leon Štukelj last decade of life, where he was ambassador of Slovenia, Gymnastics, Sport, Olympism and heathy life style. (Photo Ivan Čuk)

One part is dedicated to Leon's gymnastics and sports achivements – 6 medals (3 gold) at OG. (Photo Ivan Čuk)

THE CODE OF POINTS AND THE CAREER DEVELOPMENT IN WOMEN´S ARTISTIC GYMNASTICS

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Original article

Abstract

The premise of this article is that the rules of Women´s Artistic Gymnastics (WAG) as outlined in the Code of Points significantly affect the experiences of older gymnasts in both positive and negative ways. The aim of this study was to explore the perceptions of gymnasts, coaches, and judges on the WAG rules and the body ideals, age and career length in Brazil. We draw on qualitative interviews with a sample of two coaches and seven gymnasts from the Brazilian national team, and four judges with international experience. Both coaches and gymnasts perceived younger bodies to be more responsive to the actual rules requirements regarding difficulty and training demands. On the other hand, older gymnasts were felt to be advantaged due to being able to perform more artistically and with less mistakes. Results will allow both the FIG and the Brazilian Gymnastics Federation to reflect on the way the demands of the Code of Points affect the experiences of gymnasts. As our article finds both the rules and the established WAG culture affect gymnasts, both needs to be considered in order to keep healthy gymnasts in the sport longer.

Key words*: women's artistic gymnastics, body ideals, career development, ageing, rules.*

INTRODUCTION

When women first participated in the modern Olympic Games (OG) in 1928 in Amsterdam, gymnasts aged between 20-35 years dominated Women's Artistic Gymnastics (WAG). Although this age range remained within the sport, the demographic shifted, and by the 1970s Olga Korbut and Nadia Comaneci demonstrated that the face – and body ideal – of the sport had changed (Barker-Ruchti, 2009; Blue, 1987; Claessens, et al., 2006; Kerr, 2006; Ryan, 1995). Indeed, since then, WAG has been characterized as a problematic child sport. Partly in response to such criticisms, the Federation Internationale de Gymnastique (FIG) increased the minimum age from 14 in 1970, to 15 in 1980, and later 16 in 1997 (Anderson, 1997; Atikovic et al., 2017; Cervin, 2017; Kerr, 2006).

Although older gymnasts still competed, performed, and succeeded after the rise of the child-style body ideal in the 1970s, they received less attention from spectators and media, exacerbating the notion of WAG as a child sport (Cervin, 2016; Kerr, 2006). However, recently several gymnasts have emerged at the top international level of considerably older age. Indeed, the mean average of WAG competitors has increased from 17.6 in the 2000 Olympic Games to 20.29 in the 2016 Olympic Games (FIG, 2018). Exemplifying this trend is Oksana Chusovitina, who has competed at a remarkable 11 World Championships, including Montreal 2017, and seven OG, including Rio de Janeiro in 2016 when she was 41 years of age. Others competing in 2016 included Daniele Hypólito, the 31-year-old Brazilian gymnast in her fifth OG and Jessica Lopez, age 30, from Venezuela and Catalina Ponor, at 28, from Romania, both of whom competed in their third OG. They are high profile examples of gymnasts who are defying the adage of youth in WAG, prolonging their careers up into adulthood. This trend raises questions about the conditions that allow these and other older gymnasts to continue competing on the international stage so long, particularly, given its divergence from historical trends. In this article, we wish to examine the link between a greater number of older gymnasts performing at the highest level of competition and the rulebook for gymnastics – the Code of Points (CoP). The FIG is responsible for the CoP, updating it every four years. It prescribes all matters of gymnastics performance, judging at competitions, and gymnast and coach conduct during competitions. For the purpose of this article, we are particularly interested in gymnastics performance requirements, which gymnasts must fulfil in their routines. The FIG uses the CoP, for instance, to encourage particular movements or gymnastics styles, including acrobatics and artistry. In our examination of the connections between the older gymnast population and the requirements of the CoP, we will specifically focus on how a sample of 7 current and former Brazilian national team gymnasts and two of their coaches, and four active international judges, perceived the abilities of older gymnasts, and described the impact of the rules dictated by the CoP. We focus on these two issues because our earlier research has indicated that stakeholders' perceptions of age and performance, and CoP rules, are two elements that are changing current gymnastics ideals and norms, gymnastics performance, coaching, and the gymnast careers (Barker-Ruchti, Kerr, Schubring, Cervin, & Nunomura, 2017; Kerr, Barker-Ruchti, Schubring, Cervin, & Nunomura, 2017). We choose the Brazilian case because over the last decade, there have been eight gymnasts in the national team aged over 20 and recently, Brazilian gymnasts have achieved medals at World Cups and World Championships competitions.

In the following, we begin by covering existing literature on that describes CoP rule changes over time and the implications this has for gymnasts. We then present the research methods, and discuss the results we have found. We conclude the article with a summary of our findings.

No other sport seems to change the rules as often as Artistic Gymnastics. Atikovic et al. (2017), reported that from 1964 to the present, the WAG CoP has gone through 14 versions, and gymnasts, coaches, and judges have been challenged due to the dynamicity of the Code of Points. In Oliveira, et al. (2017), it is shown how Brazilian International brevet judges need to continuously study the CoP as element values, combinations, requirements, and deductions change regularly.

The CoP dictates the rules of the WAG competition and is usually updated every Olympic cycle. The changes have implications for the athletes' selection, development, and consequences for the prolongation of the career. Those changes vary from requirements, skills and combinations values, number of team members, apparatuses, minimum age of

participation, deductions, scoring, routine composition, etc.

According to Kerr & Obel (2014, p.3), the scoring system in WAG aims "to ensure that the winning gymnast is the one who performs with the highest levels of difficulty (what is performed), and execution and artistry (how it is performed)". In WAG, gymnasts are required to present artistic competency through dance and choreography. However, there are still discussions about the effectiveness of the CoP, as difficulty is easier to quantify than artistry (Kerr & Obel, 2014; Oliveira et al. 2017).

Since the appearance of Korbut and Comaneci, the phenomenon of "acrobatization" in the mid-70 gave rise to the introduction of younger gymnasts in WAG, as smaller and lighter bodies are biomechanically favoured for rotating and flying (Barker-Ruchti et al., 2017; Nunomura & Oliveira, 2014; Sands (2018). However, from 1977 to 1983, WAG became dominated by tiny girls performing high-level acrobatics who lacked artistic skills (Cervin, 2016, 2017; Kerr, 2006). Consequently, a number of changes took place in the 1990s. According to Atikovic et al. (2017), 1996 saw the introduction of 16 years as the minimum age for WAG participation in OG and the eradication of compulsory routines. In 2004, WAG adopted an "open-ended" scoring system, removing the perfect 10 as the highest possible score. Kerr & Obel (2014) analysed the disappearance of the 10 as maximum score and argued that "the new open-ended scoring resolved this problematic situation by enabling adequate rewarding of greater difficulty" (p.11). The authors also concluded that the new score system rewarded 'the key values of the sport', i.e., both difficulty and artistry. Given the constantly shifting goalposts of the sport due to the release of a new rulebook every four years, coupled with early selection and specialization, athlete development can be said to be closely tied to the rules of WAG.

Several studies raised the issue of age as important and significant in WAG (Anderson, 1997; Claessens et al. 2005; Leglise, 2007, 1998; Nunomura & Oliveira, 2014). Indeed, the FIG has been very concerned with this question, and its increases to the minimum age have served several purposes. Motivations have included revitalizing artistry; protecting gymnasts' health; promoting a more positive image of the sport amongst the public (Cervin, 2017); and to acknowledge medical research finding intensive training at a young age was causing a range of physical and psychological problems for WAG gymnasts (FIMS/WHO, 1998). Health problems that have been associated with high performance training and competition at a young age include deformity, eating disorders, and distorted body image (Caine et al., 2001; Cassas & Cassettari-Wayhs, 2006; Daly, Bass & Finch, 2001; Dresler et al., 1997; Lindholm et al., 1995; Martinsen et al., 2010; Mellercowicz et al., 2000; Tofler et al., 1996). Despite the FIG's concern with age, there is a dearth of research examining the perceived abilities of older gymnasts.

Dionigi (2005) argues that more research is need to understand the experiences of older athletes and the meanings that competitive sport can have for them. Similarly, Tulle (2008) argues that there is a paucity of theoretical work addressing the place of the older body in sport, while Lavallee & Robinson (2007) argue that issues around retirement need more attention in the sport of WAG, particularly in relation to the support systems around athletes and different national systems.

This study explores the understanding gymnasts, coaches, and judges have about the effects the CoP has on gymnasts' age, body type and size as well as career length. By focusing on the perspective of key stakeholders within the sport, this research has the potential to shed new light on this much-debated topic.

METHODS

The research presented in this article is part of a larger international research project entitled 'Coming of age: Towards best practice in women's artistic gymnastics', initiated in 2013 (Kerr et al. 2013). This project has gained ethical approval from the Lincoln University Human Ethics Committee (HEC 2013-42) and the School of Physical Education and Sport of Ribeirão Preto, University of São Paulo, Research Ethics Committee (CAAE N° 39848514.2.0000.5659) in 2013 and 2014, respectively.

This study focused on Brazil due to the large number of older WAG athletes in the country combined with the Brazil's international success. Selection criteria were that gymnasts needed to be/have been at least 20 years of age at the time of competing at the highest international level (WC and OG), with 20 being the minimum age in which a gymnast could have theoretically experienced two OG . We also selected those coaches and judges who were/are coaching and judging these gymnasts.

To identify suitable participants in Brazil, the lead author drew on her local WAG network and contacted the Brazilian Gymnastics Federation. We contacted each potential participant and provided the relevant project information, including ethical safeguards. Once those contacted provided written consent to participate in the study, a suitable time and place for the interview was arranged.

Participants included four gymnasts who were retired at the time of the interview and three active gymnasts. All were female, with the active gymnasts ranging in age from 25 to 31 years and retired gymnasts from 22 to 29 at the time they finished their career. All gymnasts are Brazilians from three different states. All gymnasts had been part of the national team and competed at least at the WC level and/or participated in one or more OG. The two coaches had coached the gymnasts in the study and comprised of one female coach with 27 years of experience, and one male with 33 years of experience. The four judges were all female, active and internationally experienced at the time of the interview, having judged from four to ten Olympic cycles.

One interview was held with each participant using a semi-structured interview schedule with three sections. The first section, based on an oral history approach (Denzin & Lincoln, 2005), asked participants to outline biographical information. Questions addressed their entrance into WAG, successes, coaches and coach-gymnast relationships, and training experiences. The second section, based on a thematic approach (Flick, 2005), probed ideals relating to age, body and training in high-performance WAG. The interviewees were asked to describe situations and instances where these ideals impacted their gymnastics training and/or careers. The third section employed a reflective approach (Miethling & Krieger, 2004), within which they were asked to comment on two pictures, one of a young and sexually immature and one of an older and sexually mature high- performance gymnast. Interviewees were specifically asked to comment on how they felt the gymnast would perform and be successful. In all interviews, the research team employed the interview schedule as a foundation, but followed creative interviewing principles (Douglas, 1985) to allow room for the participants to lead their interviews. Two interviews were conducted via Skype as the participants were living outside of Brazil. Interviews were conducted in Portuguese and translation into English was undertaken following each interview. Interview lengths ranged from 43 to 96 minutes. Interviews were recorded digitally, and transcribed verbatim.

The coding process involved thematic analysis as described by Braun & Clarke (2006). In a first step, the leader author familiarized herself with the interview transcripts. In the next step, an inductive analysis was performed, which involves '… a process of coding the data without trying

to fit it into a pre-existing coding frame, or the researcher´s analytic preconceptions' (Braun & Clarke, 2006, p.83). Following this, the first author used line-by-line analysis, to code the data and developed categories of analysis related to the research questions. This led to the identification of the themes: Difficulty and body and ageing; artistry, execution, and age.

RESULTS AND DISCUSSION

Two main foci of inquiry "the influence of the rules on the body type and ageing" and "the influence of the rules on the prolongation of the sporting career" guided the following presentation of findings. For each subtheme, representative quotes were chosen and translated from Portuguese into English and adjusted for readability by the main author. In line with the qualitative approach used for the study (see Braun and Clarke, 2006), we chose exemplary quotations to provide the reader with the sense of common themes that came through from the majority of the participants.

Difficulty, body, and ageing

One of the most important rationales for replacing the "perfect 10" with an open-ended scoring system was the way that it allowed a significant increase in difficulty (Kerr & Obel, 2014). Specifically, it meant gymnasts were able to raise the difficulty ceiling indefinitely depending on their abilities, rather than having a mathematical limit. In this study, we found that, from the perceptions of the gymnasts, this was a problematic change that made it difficult for gymnasts to continue. For example, one retired gymnast described: 15 years ago the rules were fine for me. I couldn´t stand competing longer with the current rules, as endurance is needed to perform 5-6 acrobatics sequences on the floor, they perform 3-4 releases on the uneven bars! I almost couldn´t perform 3 on the floor at that time! (Gymnast 5).

In this quotation, the gymnast refers to the increase in difficulty levels that occurred following the change to the open-ended Code of Points, and her own belief that she would not be longer be able to be competitive in the current environment. While this gymnast did not specifically comment on age affecting her abilities, a judge commented that older gymnasts would struggle to meet the difficulty requirements: As the score 10 is gone, the more difficulties she presents, the higher the score can be, the stronger and lighter gymnasts will be favoured. The gymnasts who are competing for about 20 years will face more difficulty as the Code of Points changed much over the time. (Judge 4).

In making this argument, this judge assumes two relationships. First, that older gymnasts are less likely to be stronger and lighter, and that second, stronger and lighter gymnasts are more likely to be able to perform more difficulty. But not all participants agreed with this point of view. Indeed, several of the gymnasts were particularly critical of the discourse that lighter gymnasts produce better performances, using the dominant American gymnasts as examples. For example:

In the past, gymnasts were considered fat because they have developed breasts, but nowadays it changed a bit due to the American gymnasts, as they are heavier and powerful. Therefore, they realize that the gymnast doesn´t need to be skinny as Khorkina to look beautiful in WAG (Gymnast 7).

Another gymnast expressed frustration over the emphasis on size rather than gymnastics, stating: "In Brazil we are too stuck on biotype, however, both slimmer and stockier can succeed in gymnastics. So, what does really matter, the size or the gymnastics?" (Gymnast 6) This point echoes the work of McMahon, Penney & Thompson (2012) in Australian swimming, where similarly, Australian swimming has been criticised for emphasising size rather than performance. This emphasis has been found to lead to a range of long-term eating disorders. The same gymnast spoke of this issue in Brazilian gymnastics as well:

In Brazil, you must be thin to be part of the national team, it happened to me, as I

was a bit over weight. It is not a norm, we see strong and stocky gymnasts in the USA and they are the best! Why in our country we should be always slim? Our gymnasts have eating disorders and eat what they want, I think it is wrong and coaches know that it is disturbing when you are overweight, but it is the same when you are underweight, maybe the last case even worse. (Gymnast 6).

Gymnast 6 refers to thinness as achieved by eating disorders being a greater problem than being overweight. Her view is backed up by some very successful international coaches from other countries, as detailed in Kerr et al. (2017) who noted the problem with the emphasis on thinness over health and like Gymnast 6, pointed to the immense success of the USA's WAG programme where the gymnasts tend to be muscular rather than thin. As Nunomura & Oliveira (2014) showed, the emphasis on thinness is particularly strong in Brazil due to the influence of immigrant Ukrainian and Russian coaches, who have advocated for thinness for many years.

These comments suggest that although the emphasis on difficulty in the Code of Points could potentially lead to an emphasis on thinness, in the Brazilian context the discourse of thinness is more likely to do the WAG Russian and Ukrainian-influenced culture. In the USA, the increased difficulty demands have instead led to the production of more muscular gymnasts, but this has not occurred in Brazil.

Artistry, Execution, and age

The majority of the participants in this study believed that the current rules favour mature and older gymnasts in terms of artistry, a finding which was also found in Kerr et. al (2016) in a sample of non-Brazilian gymnasts. Pointing to the value of artistry in the Code of Points, many saw this as an area where older gymnasts are advantaged. They described how gymnasts are better able to demonstrate the bodily expressiveness that comes with age and maturity, and this quality can counterbalance the execution of fewer acrobatics and difficulties. For example:

The acrobatic gymnast will do well when she is younger. However, when ageing, the artistic expression can appeal. (Gymnast 3)

Younger gymnasts… have limited expression and their faces show anxiety in contrast with the older gymnasts who show intense sight and powerful eyes that favour artistry. (Coach 1)

I particularly like to watch older gymnasts; they have an advantage when we think of expression. On the other hand, the younger ones are robotic and less expressive. (Judge 4)

The artistic abilities of the gymnasts were believed to be of particular importance given the FIG's recent efforts to reform the Code of Points to more strongly reward artistry (Kerr and Obel, 2014). Two judges commented directly on this change:

For two cycles, the FIG is rating the artistry in order to bring back the femininity of gymnastics, because it was becoming too mechanical and hard. I believe it will be difficult for FIG to be able to devaluate difficulty, as it is what catches attention, the first impact is difficult. Therefore, this scenario won´t change, but they´ve been trying to value the artistry component… The new Code of Points requires interaction with audience and the press, in the past expression were more valued, the current Code of Points is trying to get the art back (Judge 2)

FIG tends to stimulate women on the stage, the art, the artistry, and not only acrobatics (Judge 1).

These changes to the Code of Points were argued to advantage older gymnasts. For example: "The current Code of Points values artistry, so it will be to the advantage of older gymnasts due to their expressivity and experience". (Judge 4) Another judge related this change more directly to gymnast longevity: "When there is valuing of artistic component, it tends to keep gymnasts on the scene." (Judge 1). Clearly this final judge believed that the

emphasis on artistry was effective for inspiring older gymnasts to continue competing.

Ever since the change to the open-ended Code of Points, there has been a gradual increase in execution deductions in order to prevent the situation of gymnasts with high difficulty but poor execution winning competitions (Kerr and Obel, 2014). Several of the participants commented that this change directly benefitted older gymnasts because older gymnasts are both stronger psychologically, due to greater international experience, and because they have been performing many of their skills for many years and so have consolidated their skills to a greater level than younger gymnasts:

Matured gymnasts have more control over their emotions and it counts much, the little ones have much to learn and experience … We don´t need to train that much every day … You go to the gym and do what you have to do, don´t need to stay 8 hours! It is all automatized and the body does by itself, it is all right! (Gymnast 6)

The superior psychology of older gymnasts was perceived to be a strength by several participants. For example, one judge described:

Older gymnasts can benefit from knowledge of their own strength points to perform well. They make fewer mistakes, they are more stable and very expressive, they face judging well, and therefore, they appeal during their performance. These are the older gymnasts' advantages. (Judge 4)

The ability to make few mistakes was considered to be important in the light of the Code of Points and the heavy deductions for execution. As one judge commented: "Do not include difficulties at the expense of execution because we judges are deducting the perfection! Judging is getting tense!" (Judge 1).

One gymnast linked these ideas together, arguing that judges expect older gymnasts to be more technically correct: "Judges associate maturity with technical quality" (Gymnast 3). The assumption here is that with age, gymnasts are able to improve the technical aspects of their performance.

The gymnasts explained their ability to perform with less execution errors by discussing how as older gymnasts, they had increased knowledge about themselves and their abilities, which allowed them to be strong psychologically and make the most of their training time. This same finding was found by Barker-Ruchti et al. (2017).

For example, two gymnasts described:
I´m more focused on my goals, I don´t spend time, and I don´t make the same mistakes as earlier. I have learned and mastered many skills. (Gymnast 2)

Mature gymnasts have more control that is emotional and it counts enormously, the little ones have much to learn and experience, then it is gratifying to see women in gymnastics. We don´t need to train that much every day, it is a matter of mental preparation. You go to the gym and do what you have to do, don´t need to stay 8 hours! It is all memorised and the body does by itself, it is all right! (Gymnast 6)

Both these gymnasts emphasised how after many years of training, their bodies were now able to automatically perform the correct movements without them having to think about it. Potentially, this then allows more artistry since they have the capacity to express themselves instead of only focusing the next movement. Consequently, they felt that they made less mistakes, and were also able to train more efficiently since their bodies did not need to continue to practice so many repetitions in order to compete successfully.

CONCLUSIONS

This study found that the changes to the Code of Points have been both positive and negative for older Brazilian WAG gymnasts. Although limited by its single country focus and small sample size, the findings have some similarities with other studies of older gymnasts. On the one hand, the increased difficulty demands are thought to advantage younger rather than older gymnasts. Also, these requirements

have, in the Brazilian context, been interpreted as a reason to reinforce the need for gymnasts to be thin. This is in contrast to studies in other countries (see Kerr et. al, 2017), where coaches have been found to argue that the increased difficulty demands mean gymnasts need to be healthier to avoid injury, rather than thin. While the CoP itself does not advocate thinness, and nor is thinness on its own advantageous biomechanically (with the strength to weight ratio being the significant factor biomechanically), the cultural history of Ukrainian influence in Brazil has led to an association between increased difficulty and a strong emphasis on thinness. On the other hand, older gymnasts were felt to be advantaged due to being able to perform more artistically and with fewer mistakes, both of which have been found in previous studies using international samples (see for example, Barker-Ruchti et al., 2016; Kerr et al., 2016). Both these traits are important in the Code of Points because it aims to reward artistry and includes heavy deductions for execution errors.

With the actual open code system rewarding the key values of the sport', i.e., both difficulty and artistry, and promoting femininity and womanly bodies too, there is space for different bodies and ages to succeed in WAG. Further research would be of value examining the effects of the CoP on a range of different aged gymnasts and from a range of different countries.

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WHAT MOTIVATES PEOPLE TO PARTICIPATE IN A NON-COMPETITIVE GYMNASTICS FESTIVAL? – A CASE STUDY OF WORLD GYMNAESTRADA

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Original article

Abstract

Sport participation might have very different goals, especially for non-competitive events. This study analyses the motivation of participants to join in the XV World Gymnaestrada in Helsinki in 2015, which is considered one of the largest international non-competitive gymnastics festival worldwide. Methods: The Goal Content for Exercise Questionnaire (GCEQ) was applied to 86 adults (56 female/ 30 male) and analyzed statistically. In addition, 24 short interviews were conducted and the data were analyzed by a Content Analysis. Results: "Social Affiliation" and "Skill Development" seem to be the principal motivations. Both are more important for women than for men. "Social Recognition" was also of particular relevance for the participants. Finally, the number of WG participations shows the same tendency in motivation for beginners and very experienced participants.

Keywords: *gymnastics for all, gymnastics festivals, motivation, non-competitive sports, sport participation.*

INTRODUCTION

Massive non-competitive gymnastics events have been an integral part of the gymnastics community since the last two decades of the XIX century (Wichmann, 2014). The participation of thousands of people in this kind of gymnastics festivals still represents a contemporary phenomenon, developing and propagating a particular interest in some international sports organizations (Merkel, 2013).

According to that, the World Gymnaestrada (WG) is organized every four years since 1953 by the International Gymnastics Federation (FIG) in partnership with National Gymnastics Federations. It can be considered as one of the main international gymnastics festivals (Wichmann, 2015a, 2015b; Patricio, Bortoleto & Carbinatto, 2016), bringing a huge number of participants together,

performing in gymnastics and sharing experiences during this one-week event. The last Gymnaestrada was hosted in Helsinki (Finland) in 2015 and attracted more than 20,000 participants from 50 different nations (Paoliello et al., 2016; FIG, 2017), thereby renovating the "spirit" of the non-competitive and group gymnastics.

Contemporary demands such as health maintenance, social development and educational values have helped to make sport participation a relevant subject for researchers in the field (Lauren, Stewart & Christopher, 2017) and discussion on the agenda of many organizations (e.g., UNESCO), especially those interested in sport, such as the International Olympic Committee (IOC) (Fraser-Thomas, Côté & Deakin, 2005). Thus, the reasons for participating in recreational sports and, even more so, in high-performance sports, have constituted an important subject to the academic research (Tsai et al., 2015). Nevertheless, when we compared to high-performance sports, we do not observe the same attention regarding non-competitive sports (Ojja & Telama, 1991; Thomson, 2000), as is the case of Gymnastics for All (GfA).

However, understanding the motivation that leads to the participation at the mentioned sport event can be an important prerequisite to support the development of organizational strategies, and to optimize the organization committee work for future festivals. This information can also help to understand the role non-competitive events play in terms of sports participation (DaCosta & Miragaya, 2002).

In this sense, the main goal of this study was to identify what motivates people to participate in the 2015 edition of the World Gymnaestrada, thereby examining some intrinsic and extrinsic motivational aspects (Sebire, Standage & Vansteenkiste, 2009).

METHODS

The methodological approach comprised two steps. First, data were collected by using the Goal Content for Exercise Questionnaire (GCEQ) (Sebire, Standage & Vansteenkiste, 2008). The English version of this questionnaire was applied personally to 86 adult participants (56 females and 30 males, with age ranging from 17 to 69 years with an average value of 37.2 years). Second, and complementary, we developed a short interview with 24 participants (20 females and 4 males - age range: 18-60 years, average age: 29 years), comprising one single question: "What motivates you to take part in the World Gymnaestrada?" The data were registered using a Digital Recorder in MP3 format and then transcribed as a text afterwards. This second procedure had the purpose of validating the overall pattern of results obtained with the application of the GCEQ questionnaire.

Considering the information provided in the WG official registration system (Gymnaplana) used by the Local Organizing Committee (LOC), the total number of participants were exactly 20.473 of which 15.330 (73%) were over the age of 17, the age group that characterized the study sample.

Considering the total number of participants, females represented 83% with 17.430 (12.724 adults) and males represented 17% with 3.570 (2.606 adults), numbers that show that the sample of this study (69.1% for females and 30.9% for males – considering the questionnaires and interviews) can be considered as adequate.

The cultural and geographic diversity was taken into account to the data collection, thus having participants from 35 (70%) of 50 National Federations involved at WG.

In relation to the diversity of experience in WG's participation the sample include people from 1 to 9 participations, with an average of 2.36.

Each of the 20 items of the GCEQ questionnaire could be evaluated on a 7-point scale (Likert-type): 1-2 not at all important; 3-5 moderately important; 6-7 extremely important (Sebire et al., 2008). Data were analyzed statistically using SPSS software. In particular, we calculated a

multivariate analysis of variance (MANOVA) with gender (female vs. male) as group factor, and Social Affiliation, Image, Health Management, Social Recognition, and Skill Development as dependent variables.

Furthermore, interview data were analyzed by Content Analysis procedure (Krippendorff, 1980). According to Dart (2012, p.650), the thematic "coding scheme was based on a system of categories and sub-categories" upon the GCEQ principal factors (social affiliation; image; health management; social recognition; skill development) when the first, third and fifth factor are intrinsic factors, and the second and fourth factor represent extrinsic exercise goal content (Sebire et al., 2009).

RESULTS

First, and considering participants estimated importance in the factors of the GCEQ, a MANOVA revealed the following result: There was a tendency for an overall significant effect of gender on the dependent variables (Wilks lambda = 0.876, $F(5, 80) = 2.261$, $p = .056$). When inspecting the univariate ANOVAs, however, there was a significant effect of gender on Social Affiliation, $F(1, 84) = 4.706$, $p = .032$. The effect of gender on Skill Development showed a tendency towards statistical significance, $F(1, 84) = 3.296$, $p = .073$). Social Affiliation was more important for females than for males (mean ± SE; females: 5.79 ± 0.12; males: 5.35 ± 0.16), and skill development was also more important for females than for males (females: 5.02 ± 0.19; males: 4.47 ± 0.25). The effects of gender on image, health management, and social recognition were not statistically significant (all $p > .20$), indicating that image, health management, and social recognition were in average equally important for both, females and males (see Table 1 for an overview).

Table 1
Means and standard errors of the GCEQ subscales for females and males.

GCEQ subscale	Gender		
	Females	Males	sig.
Social Affiliation	5.79 ± 0.12	5.35 ± 0.16	p=.032
Image	3.18 ± 0.21	3.34 ± 0.28	n.s.
Health Management	4.55 ± 0.19	4.35 ± 0.26	n.s.
Social Recognition	3.85 ± 0.18	4.22 ± 0.24	n.s.
Skill Development	5.02 ± 0.19	4.47 ± 0.25	p=.073

Additionally, as can be seen from Table 1, participants evaluate Social Affiliation in average as most important, followed by Skill Development, and Health Management. Social Recognition and Image are evaluated with smaller scores. Thus, highlighting the importance of Social Affiliation as the most important goal content for both, females and males, when participating at the World Gymnaestrada, showing coherence for a non-competitive sport.

Furthermore, concerning the interviews, *Social Affiliation* and *Social Recognition* were the most outstanding categories in the speeches, with 17 nominations (71%) and 18 for the second (75%), respectively. *Health* was highlighted only by one interviewee. However, it´s important to highlight the only two categories that were chosen by men rather than by women: *Image* and *Social Recognition.*

Regarding the number of participation in WG we found:

Table 2
World Gimnaestrada participation

WG Participations	GCEQ	Interview	Sample	%
1	38	13	51	46
2	20	6	26	24
3	7	2	9	8
4	9	1	10	9
5	2	0	2	2
6	7	1	8	7
7	2	0	2	2
8	0	0	0	0
9	1	1	2	2
TOTAL	86	24	Average 2,36	100

Statistically the number of WG participations does not play a role in participant's reactions. According to that, people are rather "***s**table*" in their motives and motivations and taking part in more and more WG's may not influence this.

DISCUSSION

As is widely debated, age and gender are factors that modulate sports participation (Koivula, 1999; Molanorouzi, Khoo & Morris, 2015). Still, gender remains a central issue in sports participation (United Nations, 2005) and recent studies still point out to an imbalance situation with greater male participation in sport (Van Heerden, 2014; Eime et al., 2016). However, the higher female participation in non-competitive sports has already been reported as superior with secondary students (Recours, Souville & Griffet, 2005) as well in adult's recreational sports programs (Tsai et al, 2015). The permanence of women in sports in adulthood is also greater, as other studies show (Pacheco et al, 2014). In the case of World Gymnaestrada the participation is mostly female (83%). Previous studies reinforce our findings, reporting a greater participation of women in GfA in Portugal (Silva et al., 2016), Finland (Dufur, 2006), Japan (Soares et al., 2015), as well as in several Latin American countries (Paoliello et al., 2016) participants of WG.

Although *Skill Development* is per se not a priority feature for GfA events, it was indicated as an important motivation for participation in WG. Considering that participation in WG does not foresee many training sessions or educational activities (workshops e.g.), perhaps the possibility of display and to watch other groups performances are responsible for this type of opinion. In fact, statistically women have given more attention than men to that motivation, and a similar tendency was reported by Sirard, Pfeiffer & Pate (2006) with "middle school students".

The "sense of belonging", understood from the concept of *Social Recognition* deeply discussed by Axel Honneth (1995), seems to represent a nuclear aspect to practice the GfA and, consequently, can be observed as an important element in the WG participants' discourse (Wichmann & Jarvis, 2015). In this sense, participation at WG represents a group and national representation. Many of the respondents say they feel they belong to the "family" of gymnastics. The WG seems to produce a "collective sense" in the participants, producing a positive experience that engaging people to take part in the event following edition.

> *That's really great to be at the WG because it's a the most perfect place for young people and old people to be*

together and to practice our favorite sports, watch the others, to be together the hole day. Young, old and people from different nations together is amazing. It's a perfect place to watch all the others and I will participate forever. (Coach; women; Austria; 52 years old; 4 WG participations)

According to that, the *Social Recognition* seems to be related to the nature of WG, an event where participants are performers and also spectators (Wichmann & Jarvis, 2015). To display the group choreographies and to see what the other participants are doing emerge as a characteristic of the event building a fundamental motivation. In fact, the pleasure to show and to possibility to watch the other groups performances were emphasized by many of the interviewees. In their own words:

We are motivate to bring our team the nationally disabilities display team to World Gymnaestrada to display watch people with a learning disabilities or intellectual disabilities can achieve and with lots of time and patient. The team have been participating in the World Gymnaestrada since 1987. The majority have all the team have Down's syndrome. The ages range from 12 to 47 and they all love to show what they can do. (Coach; women; UK; 60 years old; 6 WG participations)

For me, is very interesting to come here and see gymnastics from all the world and also meet people from everywhere and just enjoy a good community and atmosphere. (Gymnast; women; Denmark; 19 years old; first WG participation)

Related to that, the *Social Affiliation* was statistically more important for *women* than for men. In recreational sport, that include GfA, as showed by Tsai et al (2015), report that "make friends" is more associated with adults female participation in sports.

It's an international event that includes so many nations. We have so much fun and contact with different cultures. We can see such different gymnastics forms, all together and we love this. It's a fun week, sleeping in schools, being together. People training for months before the WG, and when it is getting closer we fell very nervous. Definitely, it's very cool. (Gymnast; women; Germany; 27 years old; 2 WG participations)

Although the practice of physical activity and sport is increasingly associated with health maintenance (Hardman, 2001), curiously in our case WG participants did not highlight *Health* as a motivation. In the same sense, *Image* and *Fitness* was not indicated as a significant reason. Similar studies in younger populations have already revealed positive trends for this variable (Pacheco et al., 2012). In any case, Health is still a motivation present in the discourse of the participants, as we see in the words of this interviewee:

It's lovely to come here because my team includes mothers, kids, and hole family together. We do for health, happiness, and specially to meet people from different countries. (Coach; women; Mongolia; 52 years old; 3 WG participations)

CONCLUSIONS

The literature about women sport participation shows greater appreciation for motivations such as Fitness, Health and Appearance (Image). However, most of these studies were performed on participation in competitive sports and about the practice of physical activity and fitness centers. We did not find any study that discusses specific participation in non-competitive sports.

We observed that both intrinsic and extrinsic factors motivating the participation in WG. In this sense, Social Affiliation and Skill Development (intrinsic) and Social Recognition (extrinsic) were the principal

motivation reported.

From the methodological point of view the GCEQ fit well to analyze the participant motivation of a non-competitive gymnastics festival without any change/modification. However, complementary methods, including qualitative approaches, can give greater reliability to the study. For further studies we suggest the use of other GCEQ languages versions in order to enlarge the sample and access more non-English speakers.

The predominance of female participants seems to be related to the most prominent motivations reported. On the other hand, it shows that it is necessary to give more attention and try to attract more men to GfA practice and to the WG.

Finally, we agree that the "increasing participation in sport is an objective for both government and sporting organizations" (Eime et al., 2016, p.1) and need to "emphasizing that the concept of sport for all to promote cultural development, relates to policies which seek to extend the benefits of sport to as many people as possible" (Council of Europe, 1975). According to that reason non-competitive sports as GfA should have more attention from the authorities and the academic community, reinforcing the United Nations (2008) recommendations.

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WEEKLY PROFILE OF TRAINING LOAD AND RECOVERY IN ELITE RHYTHMIC GYMNASTS

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Original article

Abstract

The aim of this study is to analyze the weekly profile of internal training load (ITL) and recovery of elite rhythmic gymnasts during a season. Eight professional rhythmic gymnasts of the Brazilian senior group participated. The session rating of perceived exertion (session-RPE) and Total Quality Recovery (TQR) score were collected daily across a 37-week season. The session-RPE was collected after each session and the TQR before the first session of the day. The sum of ITL of each session of the day (dITL) and week (wITL), as well as average TQR scores, were retained for the analysis. Training monotony and strain were also recorded. For the analysis, the season was divided into preparatory period, competitive period and a period comprising the competition weeks, within the competitive period. The ITL and recovery profile were different between the days of the periods and the competition weeks. The competitive period as a whole showed higher mean wITL, dITL, and strain, and lower monotony than the others. However, during the competition weeks gymnasts presented the worst recovery and highest monotony scores, despite the lowest mean wITL and dITL. Negative correlation was found between dITL and TQR of the following day (r= -0.333; p<0.001). The ITL and recovery profile changed between the season periods and competition weeks. The training load profile of the competitive period and competition weeks did not guarantee good recovery, especially on the weekend. More variability in load magnitude is suggested, possibly including a day off, during competitive periods and competition weeks.

Keywords: *session rating of perceived exertion, Total Quality Recovery, competition, gymnast.*

INTRODUCTION

The success of training depends on the control of the relation between load, recovery, and performance (Bourdon et al., 2017; Halson, 2014). This is a very complex relation, which can lead to positive adaptations to training as well as non-functional overreaching, injury, illness, drop in performance, underrecovery, and other undesired situations (Kellmann et al., 2018; Meeusen et al., 2013; Soligard et al., 2016).

The challenge of maintaining the balance in this relation increases the importance of frequent, longitudinal, and multivariate assessments of training load and responses in the bodies of athletes (Borresen & Lambert, 2009). This situation has contributed to the development of various monitoring tools in recent years (Borresen & Lambert, 2009; Bourdon et al., 2017). The nature of modern sport, with an intense calendar of competitions and demands for ever better performance, requires precise daily control of these variables in order to enable adjustments during the training process and not after it. In this perspective, simple, inexpensive and validated tools such as session rating of perceived exertion (session-RPE) (Foster et al., 2001; Haddad, Stylianides, Djaoui, Dellal, & Chamari, 2017) and the Total Quality Recovery (TQR) scale (Kenttä & Hassmén, 1998) stand out as methods of monitoring the internal training load (ITL) and recovery, respectively.

These and other tools has been used to understand training load distribution during entire seasons (Debien et al., 2018; Malone et al., 2018; Miloski, Freitas, Nakamura, Nogueira, & Bara-Filho, 2016; Moreira et al., 2015), specific periods (Thorpe et al., 2015), and weeks (Jeong, Reilly, Morton, Bae, & Drust, 2011; Manzi et al., 2010; Timoteo et al., 2017; Wrigley, Drust, Stratton, Scott, & Gregson, 2012) in different team sports. However, there is a lack of longitudinal investigations about training load in elite rhythmic gymnastics (RG).

The majority of team sports have long competitive periods over the season, with one or two matches of distinct simultaneous championships almost every week (Debien et al., 2018; Jeong et al., 2011; Thorpe et al., 2015). On the other hand, professional RG groups usually compete four or five times across one entire season. Each of these competition moments in RG last for a few minutes (routine presentation) and a small mistake during the presentation can ruin a whole season of hard training (Dumortier et al., 2017; Victorii, Valentin, Tara, Iryn, & Ulyan, 2016). Furthermore, studies have shown that gymnastics is a very complex sport due to the elevated requirement for technical perfection (Cavallerio, Wadey, & Wagstaff, 2016) and high training load from young ages (Antualpa, Aoki, & Moreira, 2017), together with the occurrence of nutritional disturbances (Silva & Paiva, 2016), and frequent overuse injuries (Cavallerio et al., 2016; Edouard et al., 2018; Kolar, Pavletič, Smrdu, & Atiković, 2017). Moreover, the literature has shown that gymnasts are exposed to training load increases, with a drop in performance (Fernandez-Villarino, Sierra-Palmeiro, Bobo-Arce, & Lago-Peñas, 2015), added to lower stress tolerance (Antualpa, Moraes, Schiavon, Arruda, & Moreira, 2015), and sleep problems (Dumortier et al., 2017; Silva & Paiva, 2016) during competition periods.

In this way, understanding the weekly distribution of training load and recovery in elite RG during different periods across the season, as well as in the specific competition weeks, may contribute to the planning and organization of training in order to guarantee the best performance at the competition moments and minimize maladaptation in this sport. In addition, a weekly profile of training and recovery of professional athletes could help the process of development of youth gymnasts. Therefore, the aim of this study is to analyze the weekly profile of ITL and recovery of elite rhythmic gymnasts during a season.

METHODS

Eight professional rhythmic gymnasts of the Brazilian senior group participated in the current study. At the beginning of the season, the athletes presented mean ± standard deviation (SD) of age, time of experience in RG, weight, and height of 20.5±2.5 years, 14.3±2.4 years, 53.38±3.93 kg, and 1.65±0.04 m, respectively. Prior to data collection, all participants were familiarized with the tools and signed a term of consent to their voluntary participation. The study was approved by the local Ethics

Committee in Research with Humans (CAAE 41423314.7.0000.5147).

During a 37-week season, ITL and recovery of the gymnasts were monitored daily. For the analysis, the season was divided into two periods: preparatory and competitive. In addition, the competition weeks were highlighted for comparison with both periods. Table 1 presents the usual content of training sessions during the different periods and competition weeks of the season. All training sessions started with a non-standardized and individual warm-up (10 min). Ballet consisted of a regimented routine of classical ballet exercises in the bar, center and floor. Conditioning were activities designed to improve physical capacities, mainly, strength, agility, and aerobic power. Flexibility were specific activities to development of this capacity, which is very important in RG. Technical training included apparatus work, body difficulty work, as well as repetitions of isolated elements (e.g., body difficulties, dance steps, risks, exchanges and collaborations), parts and the entire routine with and without the music. In general, the number (volume) and quality (intensity) of these repetitions in technical training were planned as described in Table 2. Training organization and execution were carried out, exclusively, by the technical staff of the group, without any interference from the researchers.

The ITL was determined by the session-RPE method (Foster et al., 2001). Daily, 30 minutes after each session, athletes answered the question "How was your workout?", pointing to a value on the scale between 0 (rest) and 10 (maximal). The session ITL was calculated by the product of duration of the training session (in minutes) and the reported session-RPE score, resulting in a value in arbitrary units (AU). The daily ITL (dITL) consisted of the sum of the ITLs of all training sessions during that day and the weekly ITL (wITL) was the sum of all the sessions during that week. The dITL was classified in accordance with the range between minimal and maximal mean values observed throughout the season periods: high (≥75%), moderate-high (≥50% a <75%), moderate-low (≥25% a <50%), and low (<25%) (Debien et al., 2018; Miloski et al., 2016). Training monotony and strain were calculated based on the method of Foster et al. (2001). Monotony was determined as the ratio between wITL and its SD. Strain was determined as the product of wITL and monotony. On sessions and days off the ITL was considered zero.

The TQR scale (Kenttä & Hassmén, 1998) was used to monitor recovery. Before the start of the first training session of the day, the athletes answered the question "How do you feel about your recovery?", pointing to a value on the scale from 6 to 20. The daily and weekly averages of TQR scores were retained for analysis. TQR was not assessed on days off.

Data are expressed as means ± SD. The assumption of normality was verified by the Shapiro-Wilk test, and sphericity was assessed with the Mauchly's test. Comparisons between mean wITL, dITL, monotony, strain, and TQR between the periods and competition weeks were carried out using ANOVA with repeated measures and the Bonferroni post hoc. The same tests were used to compare dITL and TQR of each day of the week between the periods and competition weeks. Exceptionally, for comparisons between the Sundays, we used the paired *t*-test. Spearman's correlation coefficient and corresponding 90% confidence intervals (CI) were used to analyze the correlations between individual dITL and TQR score of the following day over the season. The magnitude of correlation was assessed with the following thresholds: $r < 0.1$, trivial; 0.1–0.3, small; 0.3–0.5, moderate; 0.5–0.7, large; 0.7–0.9, very large; >0.9, nearly perfect; and 1 perfect (Hopkins, Marshall, Batterham, & Hanin, 2009). Data were analyzed using SPSS software (v. 20.0, SPSS Inc, Chicago, IL, USA). Statistical significance was set as $p<0.05$.

Table 1

Training content of a typical week of the gymnasts studied, for each training period during the season, including the competition weeks.

	Preparatory		Competitive		Competition weeks	
Weeks	1st to 11th		12th to 37th		15th, 22nd, 25th, 29th, 37th	
Session	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon
Monday	Ballet (60 min) Condit. (30 min) Technical (130 min) Flexibility (20 min)	Condit. (60 min) Technical (120 min) Condit. (30 min)	Ballet (40 min) Technical (200 min)	Condit. (60 min) Technical (150 min)	Ballet (40 min) Technical (160 min)	Condit. (30 min) Technical (120 min)
Tuesday	Ballet (60 min) Condit. (30 min) Technical (120 min) Flexibility (20 min)	Condit. (60 min) Technical (120 min) Condit. (30 min)	Ballet (40 min) Flexibility (20 min) Technical (170 min)	Technical (200 min)	Travel (light warm-up at airports)	Travel
Wednesday	Ballet (60 min) Technical (160 min) Flexibility (20 min)	Off	Ballet (40 min) Technical (200 min)	Off	Ballet (30 min) Technical (120 min)	Off
Thursday	Ballet (60 min) Condit. (30 min) Technical (120 min) Flexibility (20 min)	Condit. (60 min) Technical (150 min)	Ballet (40 min) Condit. (20 min) Technical (160 min)	Condit. (60 min) Technical (140 min)	Technical (140 min)	Technical (140 min)
Friday	Ballet (60 min) Condit. (30 min) Technical (120 min) Flexibility (20 min)	Condit. (60 min) Technical (150 min)	Ballet (40 min) Technical (180 min)	Technical (200 min)	Ballet (30 min) Technical* (120 min)	Technical (140 min)
Saturday	Ballet (90 min) Technical (160 min)	Off	Ballet (40 min) Technical (150 min) Simulated presentations (30 min)	Off	Competition (qualification) (170 min)	Off
Sunday	Off	Off	Simulated presentations (90 min)	Off	Competition (finals) (120 min)	Off

*Podium training at the competition space; Condit.: conditioning

Table 2
Planned number and quality of repetitions of technical training components for each training period during the season, including the competition weeks.

	Preparatory	Competitive	Competition weeks
Body difficulties, dance steps, and risks	10	5	2
Exchange difficulties and collaborations	20	10	2
Parts of routine	6 (without music) + 4 (with music)	4 (with music)	1 (with music)
Entire routine	0	6	2
Demanded quality of repetitions	Low	Few mistakes	Without any mistakes

Table 3
Weekly and daily internal training load (AU), monotony, strain, and recovery of each period and competition weeks across the season (mean±SD).

	Preparatory	Competitive	Competition weeks
wITL	10507±1199 [b, c]	12496±524 [a, c]	8231±640 [a, b]
dITL	1501±171 [b, c]	1785±74 [a, c]	1212±78 [a, b]
Monotony	1.65±0.05 [b, c]	1.51±0.06 [a, c]	1.91±0.11 [a, b]
Strain	17098±2213 [b]	20482±953 [a, c]	17413±1768 [b]
TQR	13.66±1.31 [b, c]	12.45±1.11 [a, c]	11.46±1.20 [a, b]

Legend: wITL: Weekly internal training load; dITL: Daily internal training load; TQR: Total Quality Recovery mean score. [a] Different from preparatory period; [b] different from competitive period; [c] different from competition weeks ($p<0.05$).

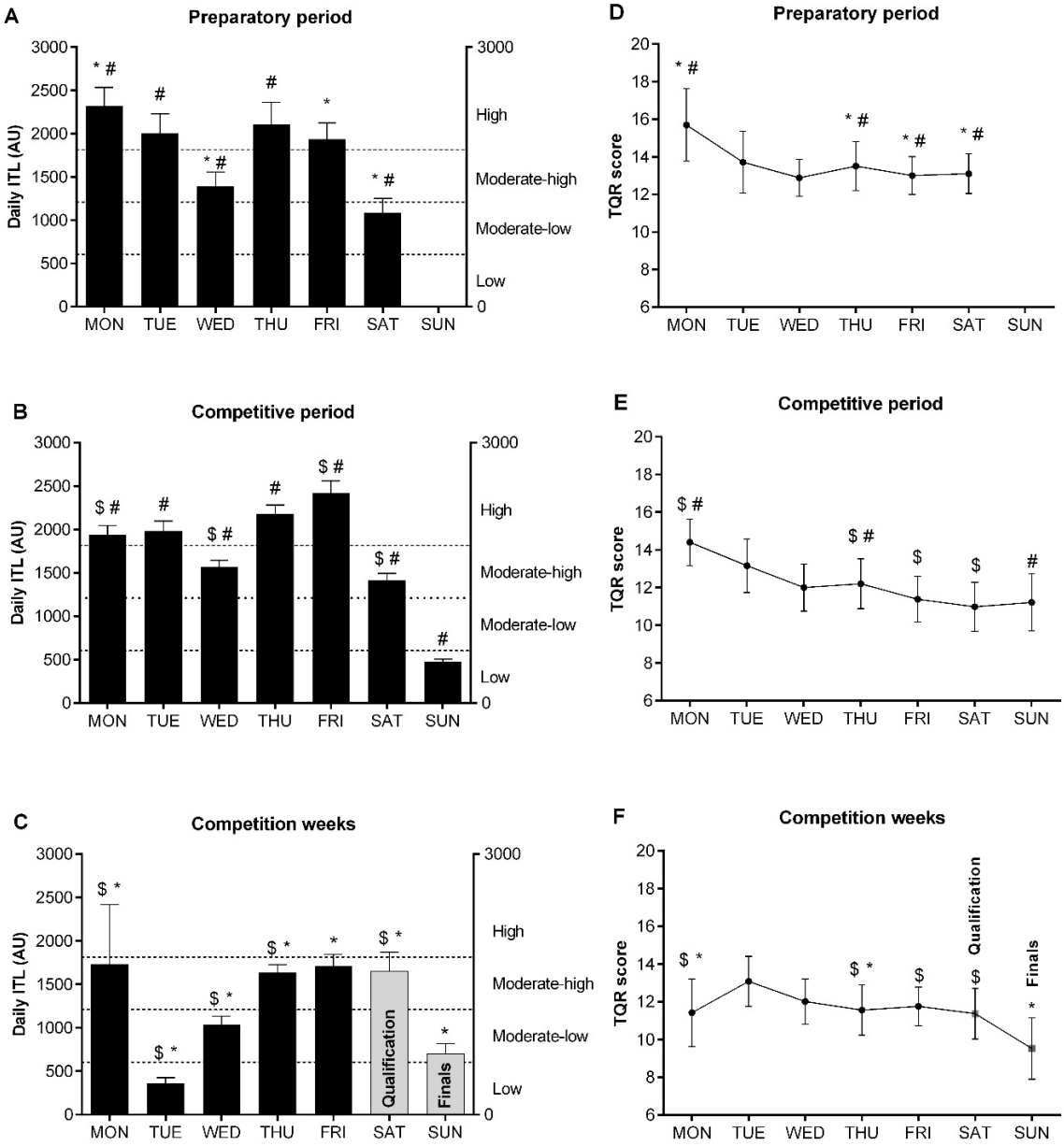

Figure 1. Weekly profile of internal training load (A, B, and C) and recovery (D, E, and F) of each period and competition weeks across the season of an elite rhythmic gymnastics group.

Legend: $^{\$}$Different from the same day of preparatory period ($p<0.05$); *Different from the same day of competitive period ($p<0.05$); $^{\#}$Different from the same day of competition weeks ($p<0.05$); ITL: internal training load; TQR: Total Quality Recovery; AU: arbitrary units; Mon: Monday; Tue: Tuesday; Wed: Wednesday; Thu: Thursday; Fri: Friday; Sat: Saturday; Sun: Sunday

RESULTS

Figure 1 displays a schematic representation of ITL and recovery weekly profiles during preparatory period (A and D), competitive period (B and E), and competition weeks (C and F), respectively. The comparison of dITL between each day of the periods and competition weeks demonstrated significant differences on Monday ($F=69.26$; $p<0.001$), Tuesday ($F=439.32$; $p<0.001$), Wednesday ($F=63.6$; $p<0.001$), Thursday ($F=43.85$; $p<0.001$), Friday ($F=43.94$; $p<0.001$), Saturday ($F=41.33$; $p<0.001$), and Sunday ($p<0.001$). The comparisons of TQR between each day of the periods and competition weeks were significantly different on Monday ($F=22.83$; $p=0.001$), Thursday ($F=20.8$; $p=0.001$), Friday ($F=13.43$; $p=0.001$), Saturday ($F=39.71$; $p<0.001$), and Sunday ($p<0.001$). The classification of dITL magnitude showed distinct distribution over the periods and competition weeks (Figure 1a, 1b, 1c). Moreover, a significant correlation was found between dITL and the TQR score of the following day ($r= -0.333$; 90% CI [-0.374; -0.295]; $p<0.001$; $N=1678$).

The mean wITL, dITL, monotony, strain, and TQR of each period and competition weeks are displayed in Table 3. When comparing wITL, there was a significant difference between periods ($F=71.29$; $p<0.001$). The post hoc analysis showed higher wITL during competitive period and lower during competition weeks, when compared to the other periods. The mean dITL was significantly different between periods and competition weeks ($F=60.46$; $p<0.001$). A higher mean dITL was observed during competitive period and the lowest during competitive weeks. The monotony also changed significantly across the periods ($F=51.92$; $p<0.001$). The highest and lowest monotony were observed during competition weeks and competitive periods, respectively, in comparison to the other periods. Strain varied during the season ($F=12.45$; $p=0.001$) and the competitive period was significantly higher than the other two periods. There was a reduction in TQR over the season ($F=22.46$; $p<0.001$). Higher TQR was observed during the preparatory period and lower across competition weeks, when compared to the other periods.

DISCUSSION

The current study explored the weekly profile of ITL and recovery across a full season of elite rhythmic gymnasts. The main findings were that both ITL and recovery weekly profiles were different between preparatory period, competitive period, and competition weeks. The competitive period showed higher wITL, dITL, and strain, besides lower monotony than the other periods. Furthermore, during competitive weeks, athletes were worse recovered than during preparatory and competitive periods. A negative moderate correlation was found between dITL and TQR of the following day. This is the first study to analyze the weekly profile of ITL and recovery in elite RG. This analysis is important to better understand the required training load and athletes' responses, and might be useful to optimize the long-term planning and control of training in RG.

The weekly profile of ITL across the preparatory period showed five days in a row, from Monday to Friday, with high or moderate-high dITL, even with just one training session on Wednesday. This wave shape of dITL magnitude is different from that observed in a pre-season of elite soccer (Jeong et al., 2011), while on the other hand, it is very similar to the weekly profile of elite women's artistic gymnasts (Dumortier et al., 2017). A different ITL and recovery profile during preparatory periods in a RG season is expected, as during this moment the focus of training is the development of flexibility, explosive strength, aerobic capacity, and less specific technical training than the competitive period (Laffranchi, 2001). This load distribution reflected positively on maintenance of appropriate recovery (at least "reasonable recovery", score 13) (Kenttä & Hassmén, 1998) all week, especially on Monday, after the load

reduction on the weekend (Leme et al., 2015). Moreover, the association of weekend load decrease, without any training session on Sunday, with a moderate-high dITL on Wednesday seems to be a good strategy to achieve higher recovery from Thursday to Saturday than during the competitive period and competition weeks in RG.

The competitive period presented an increased dITL on Wednesday, Friday, and Saturday, together with a decrease on Monday, when compared to the preparatory period. This scenario resulted in six days in a row with at least moderate-high dITL. In addition, Sunday, which is usually a day off in the preparatory period, in this period has a training session with low dITL. The load reduction on Monday was sufficient to maintain the same recovery scores as the preparatory period on Tuesday and Wednesday. However, the general increase in mean dITL and wITL impaired the athletes' recovery, especially from Thursday to Monday. At this moment of the season, the main training goal is achievement of the best technical performance, with a large number of repetitions of routine and isolated elements (Laffranchi, 2001). A deep investigation about expert development in RG demonstrated that technical training and routine repetitions required more physical effort and concentration than other parts/types of training sessions (Law, Côté, & Ericsson, 2008). Possibly, this change in training content added to the RG culture of never ending routine repetitions during competitive periods (Cavallerio et al., 2016), explains the higher ITL and impaired recovery. Ideally, this period should present a similar weekly training profile to that expected during main competitive weeks (Laffranchi, 2001), which was not observed. In RG, competitions usually occur on the weekend, which highlights the importance of greater recovery on Saturday and Sunday. An investigation of 10 training sessions during a competitive period in RG demonstrated performance decreases across the study course and suggested that better training load distribution could have minimized this drop in specific RG performance (Fernandez-Villarino et al., 2015). Furthermore, a study with professional handball players found a positive role of a passive rest weekend (two days off) for psychological and physical recovery (Leme et al., 2015). Based on these results and the higher recovery in the preparatory period, we suggest the inclusion of a day off during the week in the competitive period in RG in order to achieve better balance between load and recovery and avoid negative adaptations to training.

RG group competitions are short, usually around two or three days. Commonly, the first day is scheduled training at the competition location, called "podium training" (Dumortier et al., 2017). On Saturday all the groups present two routines in an attempt to qualify for the finals, in which the best eight ranked groups compete, summing the score of both routines. The qualification often has a longer duration, because of the higher number of presentations and the finals usually take place on Sunday morning. Each group routine takes around two and a half minutes and the presentations are interspersed by other countries, so that no group presents two routines in sequence. In this scenario of competition, it is essential that the weekly profile of training load provides the best recovery and performance on the weekend, as already mentioned. Contrasting this expectation, the present study results revealed the worst season recovery during the competition weeks, mainly on the weekend. The weekly ITL profile showed a completely different wave of magnitude than typically reported by the gymnasts over the season. Furthermore, the lowest mean wITL and dITL of the season was not enough to recover the gymnasts, reaching the lowest mean TQR score during competition weeks.

Moreover, the low dITL on Tuesday, as a consequence of traveling to the competition, is followed by a progressive load increase until the podium training on Friday. Despite the distinct physiological

demand on a competition day in RG (Douda, Toubekis, Avloniti, & Tokmakidis, 2008), normally, team sports present a profile of daily load reduction until the match day, including a day off during the 7-day microcycle that involves the match (Malone et al., 2018; Manzi et al., 2010; Thorpe et al., 2015; Wrigley et al., 2012). It is worth noting that Malone et al. (2018) also found a negative moderate relation between the dITL and athlete wellness perception the next day of a professional goalkeeper, added to which, this approach of load reduction prior to the match day reflected positively on wellness score on the match day. Similarly, even during a very congested competition week, professional volleyball players perceived an improvement in recovery and state of well-being after a day off on Wednesday (Timoteo et al., 2017). The loads in competition weeks should be managed carefully and individually in RG, and a weekly profile of dITL reduction until podium training, added to a day off could provide greater recovery and performance in qualifications and finals.

Recovery is a multifactorial process that depends on time and is also impaired by training load, travel, nutrition, sleep disturbances, impaired social environment, and psychological stress (Kellmann et al., 2018), which are common during competition weeks. In RG, studies have shown that during competitions, gymnasts present overuse injuries (Edouard et al., 2018), low energy availability (Silva & Paiva, 2015), as well as poor sleep habits and nutrient deficiencies (Silva & Paiva, 2016). These outcomes are extremely opposed to those desired in the principal weeks of the entire season. Moreover, in the case of Brazilian gymnasts, the long-distance air travels to compete in other continents exposes them to travel fatigue and jet lag, which could also impair their recovery and performance during competition weeks (Dumortier et al., 2017; Soligard et al., 2016). It highlights the need for expressive changes in the weekly profile of training load during RG competitions, along with reflection about the consequences of RG culture on athlete performance and health, especially across these weeks.

In addition to the lower wITL, dITL, and TQR score, competition weeks also showed the highest monotony. Elevated loads across competitive periods are uncommon in other sports (Debien et al., 2018; Miloski et al., 2016; Moreira et al., 2015), mainly because of the precaution about athlete recovery during this period. Instead, the RG competitive period showed the highest training loads of the season. The literature suggests that training monotony and increases in strain are related to incidences of illness and injuries (Foster, 1998), and this should be avoided to prevent the occurrence of these kinds of maladaptation (Meeusen et al., 2013). However, corroborating the results of the current study, Dumortier et al. (2017) found high training monotony and strain in female artistic gymnastics due to the long training sessions. At same time, seasonal training monitoring of professional volleyball players found small negative correlations between TQR and training monotony (Debien et al., 2018). The variability in dITL magnitude is essential to recover athletes across the week, as well as avoid negative adaptations to training. These results confirm and reinforce the need for better dITL distribution during competition weeks in RG, with more low loads or even a complete day off.

Regardless of the pioneering and novel results, the present study has some limitations. Other national RG groups could present different weekly profiles of training load and recovery. In addition, the absence of precise external training load and performance assessments, as well as physiological variables are also limitations. However, our findings could benefit RG coaches and practitioners with training planning and daily control. Moreover, the association of a daily load and recovery management with long-term planning might optimize adjustments during the process and minimize maladaptation in RG. Other

investigations could describe different national groups or even junior groups, as well as test the effects of specific experimental training weekly profiles.

Finally, in view of national RG groups working in a permanent way, the harmony between the gymnasts (Victorii, Valentin, Tara, Iryn, & Ulyan, 2016) and their adaptation to the process (not only training) are very important for success. Hence, specific knowledge about the weekly profile of ITL and recovery might be helpful to gymnasts that aspire to achieve this dream. In this way, these results could bridge the gap of the training reality between the clubs and national RG groups. Furthermore, our findings may facilitate the adaptation of gymnasts not only to high training loads, but also to other impairments in social life.

CONCLUSIONS

The weekly profiles of ITL and recovery differed between the season periods and competition weeks in an elite RG group. The competition weeks need special attention from coaches during planning and execution, as athletes should be prepared to reach their best performance towards the end (e.g., Friday, Saturday, and Sunday). A simple load reduction during competition weeks was not enough to improve the recovery of the gymnasts, which emphasizes that the daily load magnitude distribution over the week, as well as the frequency of training sessions are also very important. In general, the gymnasts did not achieve full recovery, even after a day off and were not capable of recover properly during the weeks. Our findings highlighted that daily control of ITL and recovery are essential to optimize the training process. Moreover, session-RPE and TQR seem to be useful tools to monitor ITL and recovery in RG.

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BODY DIFFICULTIES IN RHYTHMIC GYMNASTICS ROUTINES

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Original article

Abstract

The aims of this study were: (1) to analyze the diversity and variety of body difficulty elements in individual routines of elite rhythmic gymnasts that competed at the 2013 and 2014 Lisbon World Cup; (2) to compare these characteristics across different ranking groups; (3) to identify and hierarchize the variables that most contribute to the success in the difficulty score in competition. 288 routines were analyzed based on difficulty, according to the 2013-2016 Code of Points. The gymnasts were divided into three groups according to their ranking routine. For statistical analyses, Kruskal-Wallis' and Mann-Whitney's non-parametric tests, Pearson Correlation and multiple regression were used. Among all body difficulties, the rotation elements were the group with the most variety, while jump elements had the least variety. Gymnasts tend to use the same jumps, balance elements and rotations in all their routines. The gymnasts in the finals (finalists) presented a higher number of complex elements (mixed and multiple difficulties) than the other groups. However, the best gymnasts showed a lower variety in the choice of body difficulties. Their routines focused on rotation elements and number of turns. Lower occurrences of balance and jump elements were verified. We identified the following hierarchy of importance of the variables that contribute to the success in the difficulty score: value of rotations; value of jumps; value of balance elements and value of mixed difficulties. Therefore, the rotation elements presented a higher importance in the routines in RG in the Olympic cycle 2013-2016.

Keywords: *body difficulty, rhythmic gymnastics routines, elite gymnasts.*

INTRODUCTION

The first time that a Rhythmic Gymnastics (RG) individual participated in the Olympic Games was in 1984 in Los Angeles. Since then, the standard of individual performance has improved tremendously. The development of RG and the increased complexity in competition routines are reflected in the continuous revisions and changes of the international competitive RG Code of Points (RG-CoP) (Sierra-Palmeiro, Fernández-Villarino, & Bobo-Arce, 2015). Every 4 years, at the end

of the Olympic Games, this Code is improved and published by the International Gymnastics Federation (FIG) (Ávila-Carvalho, Palomero, & Lebre, 2010) with the main purpose of providing a more objective evaluation of the competition routines and promoting the development of the sport (Ávila-Carvalho, Klentroub, Palomero, & Lebre, 2012).

In the Olympic cycle 2013-2016, the performance in competition was evaluated by 2 panels of judges: one for difficulty and one for execution. The difficulty jury of individual programs consisted of the analysis of the four difficulty elements: body difficulties (BD), dance steps, apparatus mastery and dynamic elements with rotation and throw (DER). At each competition, the gymnasts presented an official difficulty form with all difficulties listed (Leandro, Ávila-Carvalho, Sierra-Palmeiro, & Bobo-Arce, 2015). The execution jury evaluate the quality of the routines (Leandro et al., 2015) and applies the technical and artistic faults (FIG, 2012).

Gymnasts can incorporate 6 to 9 body difficulties in one routine – a minimum of 2 and a maximum of 4 body difficulty elements from each body group: jumps, balance elements and rotations (FIG, 2012). There are 146 different samples of BD in five levels which were used isolated, in series (jumps or pivots), mixed and/or multiples (only pivots) (FIG, 2012). The distribution of these BD in the RG-CoP was as follows: 50 jumps, 50 balance elements and 46 rotations. Specific additional criteria to each body group could be included in the BD elements.

According to Agopyan (2014), we can detect the effects of the RG-CoP rules in the routines through the analysis of elite RG routines; however, the author explains that very few studies have analyzed the difficulty elements used in elite RG individual routines. For E. Lebre (1993), the probable justification is the constant evolution of the RG-CoP requirements, regarding both the composition and the implementation. Thus, it becomes difficult to compare the results.

Quantitative information obtained from the analysis of the elite routines is important because this data allow us to identify the main areas and categories of elements used, and study the relative importance of these elements, which can meet the current trends of RG, promoting a better training process.

Therefore, the aims of this study were to analyze the BD diversity and variety of elements used in individual routines of elite rhythmic gymnasts who competed at the 2013 and 2014 Lisbon RG World Cup, and to compare these characteristics across different ranking groups. In addition to this, the aim was to identify and hierarchize the variables that most contribute to the success in the difficulty final score in competition.

METHODS

A total of 288 individual routines from 31 countries performed at the 2013 and 2014 Lisbon RG World Cup (Portugal) were analyzed according to the 2013-2016 RG-CoP rules (FIG, 2012). This study was approved by the RG World Cup Organization.

Each participant performed 4 routines (hoop, ball, clubs and ribbon) and the analysis was carried out based on the difficulty forms submitted prior to the competition by the coaches, and not evaluated by the judges.

The gymnasts were divided into three groups according to their ranking routine in each apparatus: 1st group (Finalists) – 1st to 8th place in the ranking; 2nd group – 9th to 22nd place in the ranking; 3rd group – 23rd to 36th place in the ranking.

The analysis was conducted by two international RG judges. The high intra-class correlation coefficient values in the relative reliability analysis – intra-examiner (0.98) and inter-examiner (0.97) – demonstrated high objectivity in the evaluations.

For statistical analyses of the data, the Statistical Package for Social Sciences 20.0 was used. The level of significance was set at $\alpha = 0.05$. Descriptive statistics were calculated using the mean, standard

deviation (SD) and range values. Kruskal-Wallis' and Mann-Whitney's non-parametric tests were used to compare the ranking groups. Pearson Correlation and multiple regression were performed to analyze the association and degree of influence of the BD in the gymnasts' difficulty final score.

RESULTS

Body Difficulties (BD): 97.6% of the routines presented the maximum number of BD (9). Figure 1 shows that the most routines presented a predominance of rotation elements (54.4%) and lower predominance of balance and jump elements were verified.

Number and Type of BD: We observed 25 different shapes of jump elements, 21 balance elements and 27 rotation elements in the routines. The BD per body group were divided into subgroups, based on the RG-CoP criteria (different rows according to the body's group's characteristics).

Jump Elements: Table 1 presents the jump elements from the RG-CoP (FIG, 2012) used at the 2013 and 2014 Lisbon World Cup. The jump elements most used in the routines were no. 18 (62.5%); no. 20 (53.1%) and no. 15 (35.5%).

The jump elements preferred by finalists are displayed in Figure 2: no. 18 (57.8%), no. 20 (56.3%), no. 15 (34.4%), no. 17 (32.8%) and no. 21 (21.9%). This type of jump "jeté with turn" contains the highest values in the RG-CoP (FIG, 2012).

Significant differences were found in the ranking groups in jumps no. 18, 20, 15 and 17 (see Table 1). The 3rd group of gymnasts showed a significantly higher number of jumps no. 18 ($p \leq 0.05$). The finalists and 2nd group incorporated a similar number of this BD. Significant differences in the jumps no. 20 and 15 were verified in the 2nd group versus the 3rd group ($p<0.001$). It can be seen that the 2nd and 3rd groups had a higher and a lower number of these jumps in the routines, respectively. The finalists presented the highest number of jumps no. 17 and 21 compared to the remaining groups, although significant differences can be observed only in jump no. 17 in the finalist group versus the 2nd group ($p=0.002$) and finalists versus the 3rd group ($p<0.001$).

Figure 3 shows the jump elements least used by finalists: no. 19 (9.4%), no. 11 (6.3%), and no. 7 (3.1%). Jumps no. 2, 8, 9, 10, 12, 16, 23 and 24 were used only in 1.6% of the finalists' routines. However, no significant differences were found between ranking groups.

Figure 3 also includes the jump elements not used by finalists (see Table 1). Jump elements were not frequently used in routines, therefore, no significant differences were found between ranking groups.

Balance Elements: Table 2 presents the balance elements from the RG-CoP (FIG, 2012) used at the 2013 and 2014 Lisbon World Cup. The balance elements most used in the routines were no. 16 (68.8%); no. 13 (49.0%); no. 14 (48.3%) and no. 15 (39.9%).

Figure 4 displays the balance elements used by finalists: no. 15 (62.5%), no. 13 (53.1%), no. 14 (50%), no. 16 (48.4%), no. 10 (26.6%), no. 3 (15.6%) and no. 17 (14.1%). These balance elements (except no. 3) are executed with the free leg high up in different directions; body at the horizontal level or below, with or without help.

Significant differences were found in the ranking groups in balance elements no. 15, 16 and 10 (see Table 2). We verified a significantly higher number of balance elements no. 15 in the finalists' routines. Significant differences were observed in the finalists versus the 2nd ($p=0.003$) and 3rd ($p=0.022$) groups. Conversely, the finalists presented a lower number of balance elements no. 16 when compared to the other groups. Significant differences were observed in the usage of balance element no. 16 by the finalists versus the 2nd ($p<0.001$) and 3rd ($p=0.039$) group. Balance elements no. 10, 3 and 17 were mostly used by finalists and least used by the 3rd group, however, significant differences were only observed in balance element no. 10, in the

finalists and 2nd group versus the 3rd group ($p<0.001$).

Figure 5 shows that the balance elements least used by finalists were no. 6 and 18 in 3.1% of the routines, and no. 1, 9 and 19 in 1.6% of the routines. Balance element no. 18 was most used by the 2nd and 3rd groups than by the finalists. Therefore, significant differences were found in the finalists versus the 2nd ($p=0.006$) and 3rd ($p=0.013$) groups.

We verified significant differences in the finalists and 2nd group versus the 3rd group ($p\leq0.05$) in some balance elements that were not performed by finalist gymnasts (Figure 5): no. 4, 11 and 20.

Balance Elements on Flat Foot: According to the RG-CoP (FIG, 2012), the balance elements may be performed on flat foot. 9.4% of the finalists, 23.2% and 11.6% of the 2nd and 3rd groups, respectively, included one balance element on flat foot. The balance element most used (91.1%) on flat foot in all groups was no. 16 (see Table 2). The other balance elements used on flat foot were no. 17 and 14 (see Table 2).

Rotation Elements: Table 3 displays the rotation elements from the RG-CoP (FIG, 2012) used in the 2013 and 2014 Lisbon World Cup. The rotations most used in the routines were no. 26 (80.2%); no. 6 (66.3%); no. 12 (49%); no. 22 (34%); no. 13 (23.3%); no. 1 (16%); no. 18 (14.6%); no. 23 (12.8%); no. 3 (12.5%).

Among the rotation elements most used by finalists (Figure 6), we observed the same main rotation elements in all groups: no. 26, 6 and 12 (see Table 3).

According to Figure 6, significant differences were found in the ranking groups in rotations no. 6, 23, 13, 25 and 9 (see Table 3). The finalists showed a higher number of these rotations in their routines when compared to the other groups, except in rotation no. 13, which the 2nd group presented a significantly higher number ($p\leq0.05$). In rotation no. 6, we can see differences in the finalists and 2nd group versus the 3rd group ($p<0.001$). Significant differences also were found in the finalists versus the 2nd group ($p<0.001$) in rotation no. 23, finalists versus the 3rd group ($p=0.005$) in rotation no. 25, and finalists versus the 2nd ($p=0.013$) and 3rd ($p=0.002$) groups in rotation no. 9.

In Figure 6, we observed that the 3rd group presented a higher number of less complex rotations (no. 22 and 1) than the other groups.

The rotation elements least used by finalists and the rotation elements not used by this group were shown in Figure 7. Rotations no. 2, 3, 10 and 21 (see Table 3) were used by finalists only in multiples difficulties.

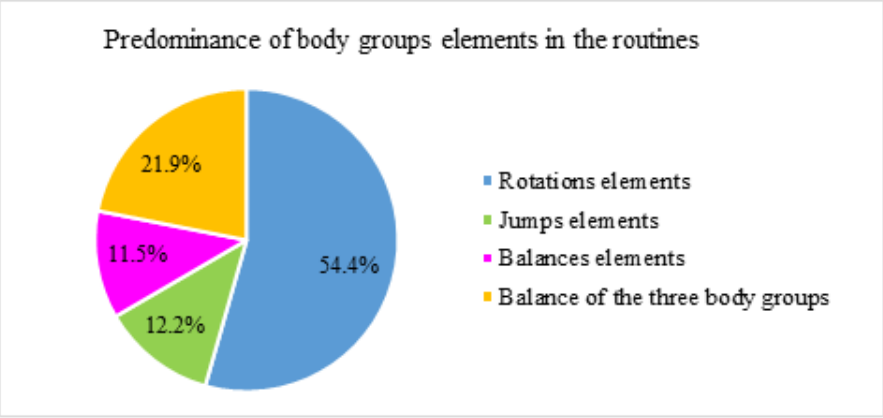
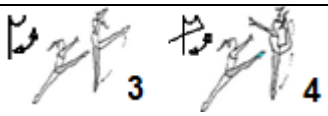
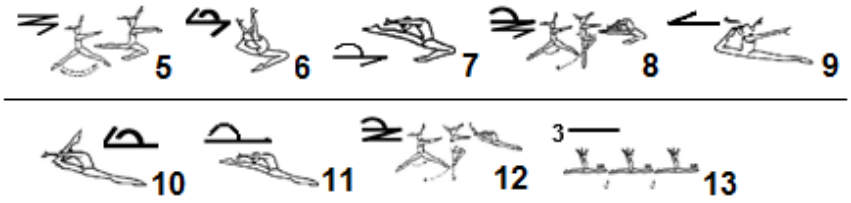
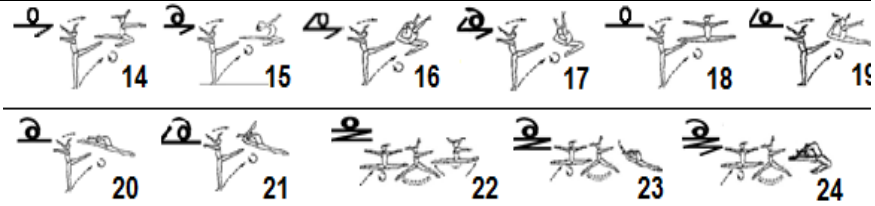


Figure 1. Predominance of body groups elements in the routines.

Table 1
Jump elements (images and symbols) used in the Rhythmic Gymnastics routines.

Jump images and symbols from the RG-CoP (2013-2016)	
Straddle jumps	
"Cossack"	
"Entrelacé"	
Split and stag leaps	
Turning split leaps	
Butterfly	

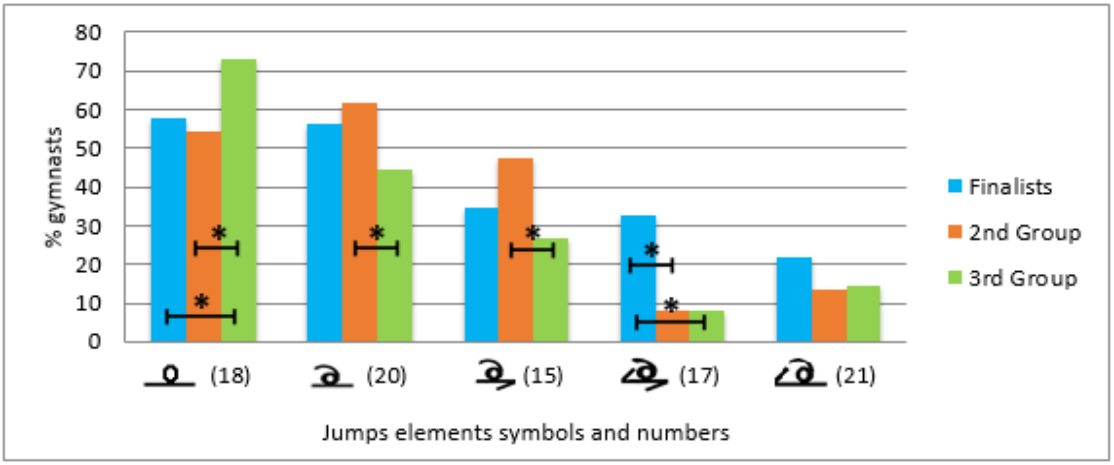


Figure 2. Jumps most used by the finalists in the routines, grouped by ranking position. (* p ≤0.05: Significant differences)

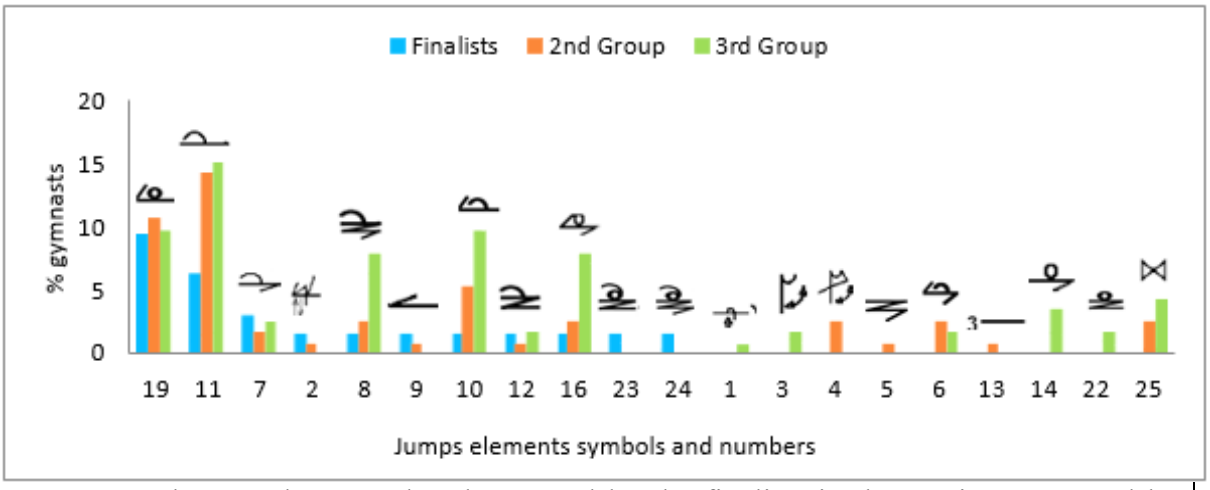
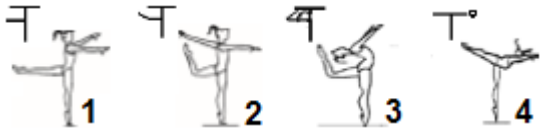
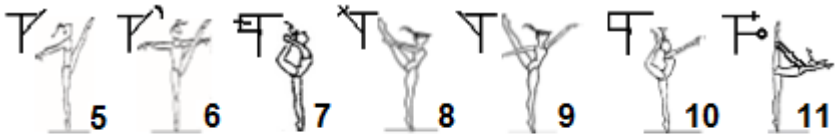
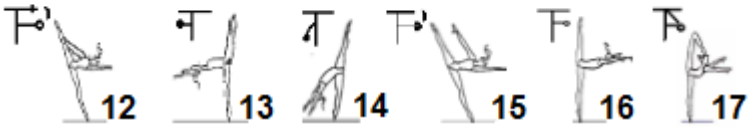


Figure 3. Jump elements least used and not used by the finalists in the routines, grouped by ranking position.

Table 2
Balance elements (images and symbols) used in the Rhythmic Gymnastics routines.

Balance images and symbols from the RG-CoP (2013-2016)	
Free leg at horizontal level in different directions, body bent forwards, backwards, sideways	
Free leg high up in different directions; body at the horizontal level or below, with or without help	 
Fouetté (min. 3 different shapes without help of the hands, on "relevé" with a min. of 1 turn of 90º or 180º)	 Leg above horizontal for 2 shapes min+ min 1 turn
Dynamic balance with full body wave	
Dynamic balance with or without leg movement with support on various parts of the body	

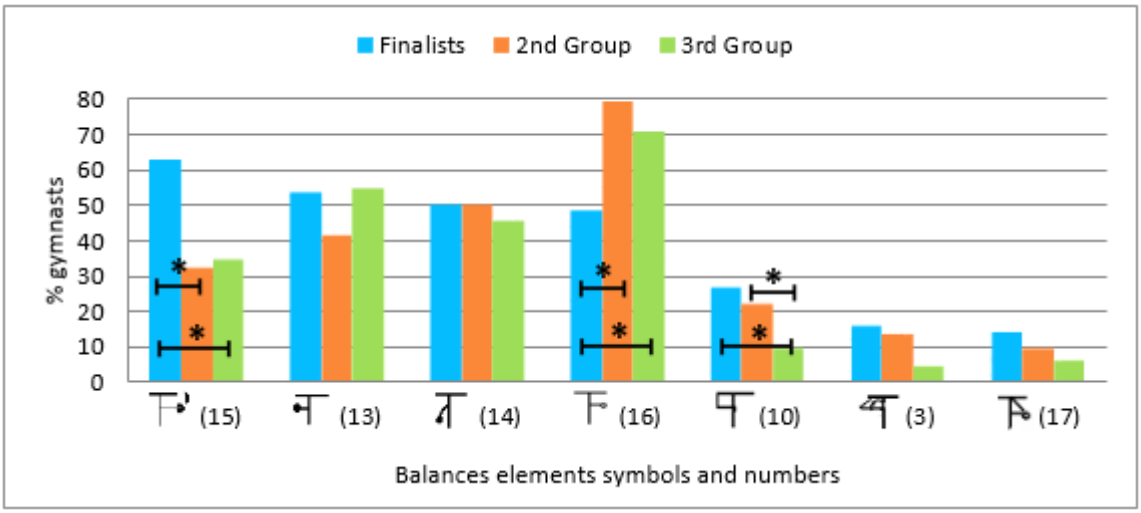


Figure 4. Balance elements most used by the finalists in the routines, grouped by ranking position (* p ≤0.05: Significant differences).

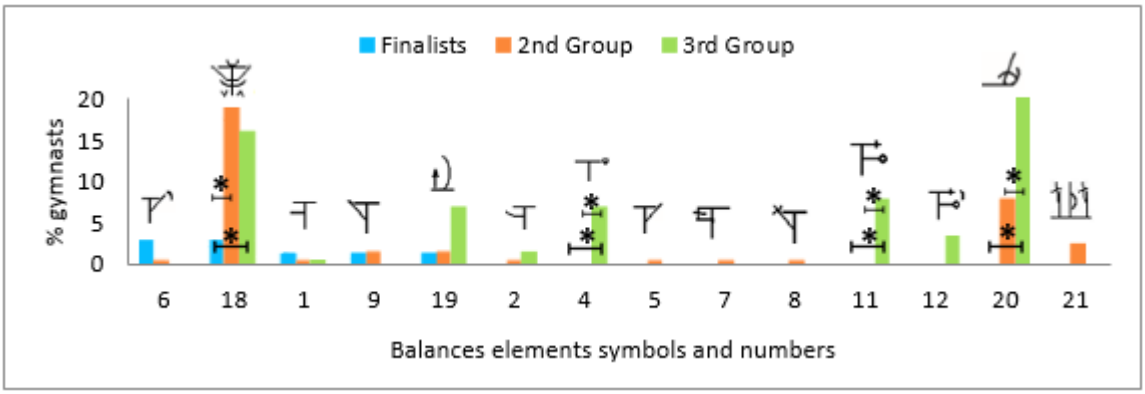


Figure 5. Balance elements least used and not used by the finalists in the routines, grouped by ranking position (* p ≤0.05: Significant differences).

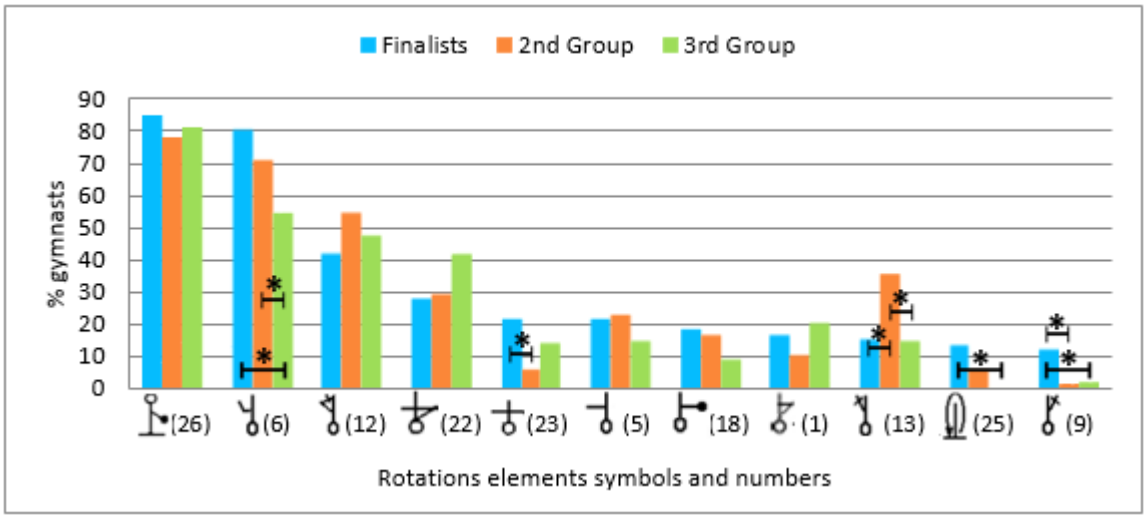
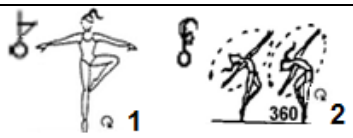
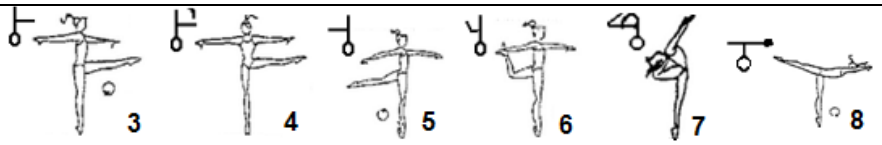
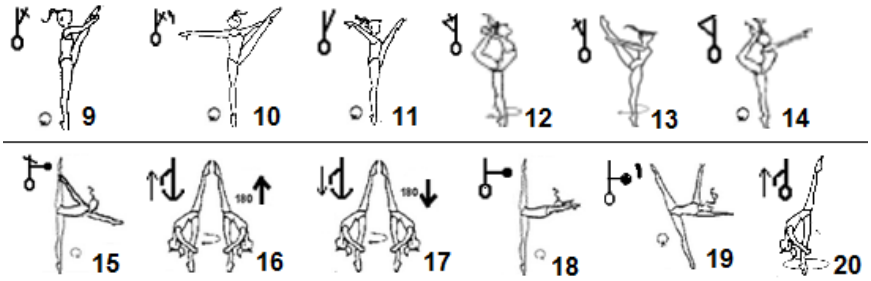
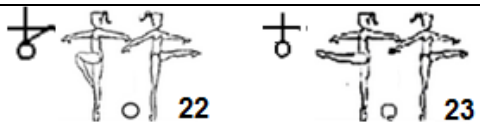


Figure 6. Rotation elements most used by the finalists in the routines, grouped by ranking position (* p ≤0.05: Significant differences).

Table 3
Rotation images and symbols used in the Rhythmic Gymnastics routines.

Rotation images and symbols from the RG-CoP (2013-2016)	
"Passé" Free leg below horizontal, body bent forward or backward; Spiral turn with wave ("tonneau")	
Free leg straight or bent on the horizontal level; body bent on the horizontal level	
Free leg high up with or without help; body bent on the horizontal level or below horizontal	
«Cossack» (free leg on the horizontal level)	
«Fouetté»	
"Illusion" forward, side, backwards; Spiral turn with full body wave; penché rotation	
Rotation on various parts of the body	

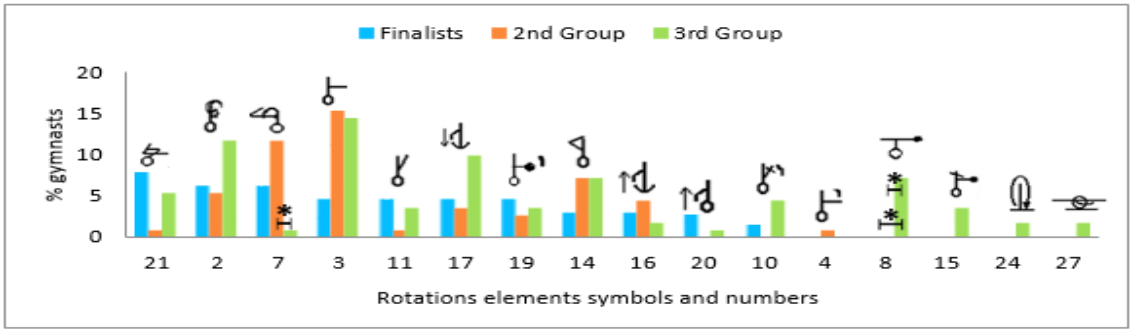


Figure 7. Rotation elements least used and not used by the finalists in the routines, grouped by ranking position (* p ≤0.05: Significant differences).

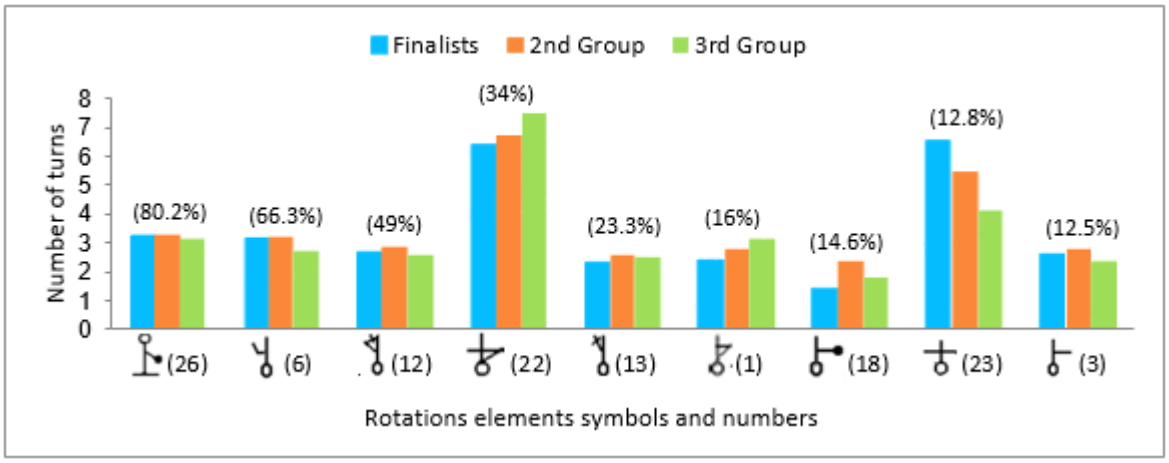


Figure 8. Number of turns in rotations used in the routines, grouped by ranking position.

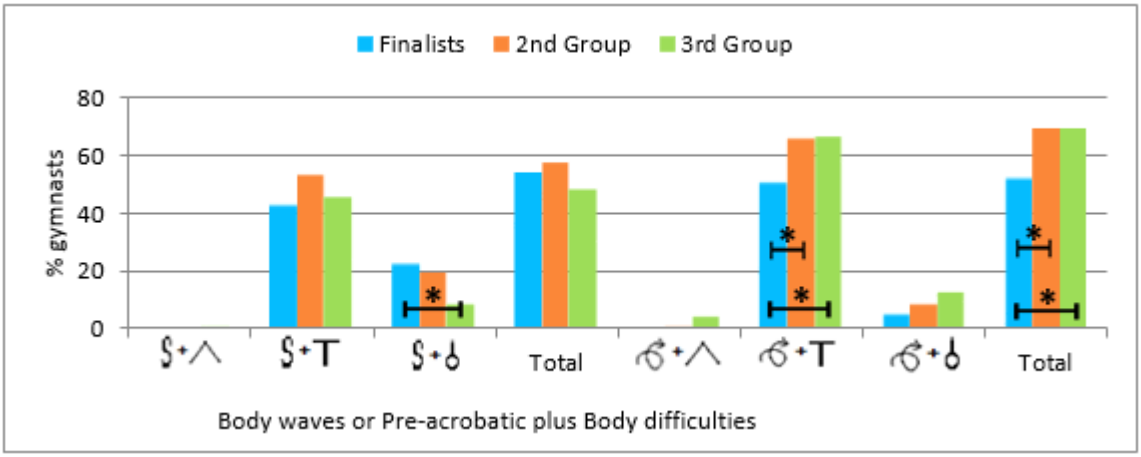


Figure 9. Body difficulties combined with whole body waves or pre-acrobatic elements in the routines, grouped by ranking position.

Legend: S - whole body waves; - pre-acrobatic elements; - jumps; - balance elements; - rotations; * p ≤0.05: Significant differences.

Table 4

Number of turns in rotation elements most used in the routines, grouped by ranking position.

Finalists (n=64)			2nd group (n=112)			3rd group (n=112)		
Rotation no.	% gymnasts	x ± sd	Rotation no.	% gymnasts	x ± sd	Rotation no.	% gymnasts	x ± sd
26	84.4%	4.33±2.50	26	77.7%	3.26±0.62	26	80.4%	3.11±0.64
6	79.7%	3.20±0.91	6	70.5%	3.17±0.78	6	54.5%	2.74±0.73
12	42.2%	2.74±0.45	12	54.5%	2.82±0.56	12	47.3%	2.60±0.53
22	28.1%	6.39±4.14	22	29.5%	6.64±2.29	22	42.0%	7.40±1.69
23	21.9%	6.57±2.50	13	35.7%	2.60±0.63	1	20.5%	3.13±1.42
5	21.9%	2.79±0.70	5	23.2%	2.92±0.69	13	15.2%	2.47±0.52
18	18.8%	1.50±0.67	18	17.0%	2.35±0.46	5	15.2%	3.06±0.43
1	17.2%	2.45±1.04	3	15.2%	2.76±0.83	23	14.3%	4.13±1.15
13	15.6%	2.40±0.52	7	11.6%	2.15±0.69	3	14.3%	2.38±0.62
25	14.1%	4.33±2.50	1	10.7%	2.75±0.87	2	11.6%	1.00±0.00
9	14.1%	2.22±0.67	14	7.1%	1.50±0.54	18	9.8%	1.82±0.75
21	7.8%	1.40±0.55	25	6.3%	5.50±1.06	17	9.8%	-
19	7.8%	1.00±0.00	23	6.3%	5.43±1.49	8	7.1%	3.13±0.35
2	6.3%	1.25±0.50	2	5.4%	1.00±0.00	14	7.1%	1.88±0.35
7	6.3%	2.00±0.00	16	3.6%	-	21	5.4%	4.33±2.50
3	4.7%	2.67±0.58	17	3.6%	-	10	4.5%	1.60±0.55
11	4.7%	2.00±0.00	21	0.9%	1.00±0.00	15	3.6%	1.50±0.58
16	4.7%	-	19	0.9%	1.00±0.00	19	3.6%	1.25±0.50
17	4.7%	-	11	0.9%	2.00±0.00	11	3.6%	2.00±0.00
14	3.1%	1.00±0.00	9	0.9%	3.00±0.00	9	2.7%	2.67±0.56
20	3.1%	-	4	0	0	16	1.8%	-
10	1.6%	1.00±0.00	8	0	0	24	1.8%	4.50±0.71
4	0	0	10	0	0	27	1.8%	1.00±0.00
8	0	0	15	0	0	20	0.9%	-
15	0	0	20	0	0	4	0.9%	1.00±0.00
24	0	0	24	0	0	7	0.9%	2.00±0.00
27	0	0	27	0	0	25	0.9%	5.00±0.00

Table 5

Total jumps, balance elements and rotation values in the routines, grouped by ranking position.

	Finalists (n=64)			2nd group (n=112)			3rd group (n=112)			P-Value
	x ± sd	Min	Max	x ± sd	Min	Max	x ± sd	Min	Max	
Jumps*1	1.57±0.40	0.7	2.6	1.45±0.42	0.7	2.7	1.44±0.44	0.5	2.9	p=0.232
Balances*2	1.44±0.42	0.8	2.3	1.50±0.38	0.8	2.4	1.52±0.36	0.6	2.4	p=0.119
Rotations*1,2	3.04*±0.78	1.0	4.4	3.13*±0.76	1.2	5.2	2.72*±0.76	0.9	4.3	F vs.3rd: p=0.018 2nd vs 3rd : p=0.002

Legend: *1 Jumps vs. Rotations; *2 Balances vs. Rotations; * p ≤0.05: Significant differences

Table 6
Body group values in the routines, grouped by ranking position.

Body group values		Finalists (n=64)			2nd group (n=112)			3rd group (n=112)		
		x ± sd	Min	Max	x ± sd	Min	Max	x ± sd	Min	Max
Jumps	>0.50	0.92*±0.66	0	2.20	0.70±0.53	0	2.20	0.57*±0.54	0	2.30
	0.50	0.59±0.40	0	1.50	0.63±0.39	0	1.50	0.70±0.41	0	2.00
	0.40	0.03*±0.11	0	0.40	0.08±0.17	0	0.80	0.11*±0.18	0	0.40
	0.30	0.01±0.06	0	0.30	0.01±0.06	0	0.30	0.02±0.07	0	0.30
Balances	0.50	1.16±0.39	0	2.00	1.17±0.44	0	2.00	1.14±0.51	0	2.00
	0.40	0.18±0.25	0	0.80	0.18±0.22	0	0.80	0.23±0.31	0	1.20
	0.30	0.19±0.73	0	0.30	0.21±0.09	0	0.60	0.30±0.10	0	0.60
Rotations	0.50	0.20±0.36	0	1.50	0.18±0.41	0	1.50	0.12±0.32	0	1.50
	0.40	0.84±0.47	0	1.80	0.83±0.51	0	2.00	0.90±0.42	0	2.80
	0.30	1.65*±0.93	0	3.30	1.75*±0.81	0.60	3.60	1.21*±0.75	0	2.70
	0.20	0.23±0.38	0	1.50	0.12±0.27	0	1.40	0.16±0.25	0	0.90
	0.10	0.23*±0.38	0	1.50	0.23*±0.35	0	1.40	0.41*±0.47	0	2.20

* $p \leq 0.05$: Significant differences

Significant differences were verified only in rotation no. 7 in the 2nd versus 3rd group (p=0.014), although the 2nd group showed a higher number of this rotation than the other ranking groups.

The rotation elements not used by finalists were present mostly in routines of the 3rd group. Significant differences were found in the ranking groups only in rotation no. 8. Because only the 3rd group had this rotation in routines (7.1%), we verified differences in the finalists and 2nd group versus the 3rd group (p<0.001).

Number of Turns (complete rotations of 360º) in Rotation Elements: Figure 8 displays the number of turns in the rotation elements most used in the routines. The rotation elements with the highest number of turns in the finalists' routines were no. 23, 22, 26 and 6; in the 2nd group, the rotations were no. 22, 23, 26 and 6; and in the 3rd group the rotations were no. 22, 23, 1 and 6.

Table 4 presents the number of turns in all rotation elements used in each ranking group.

The rotation elements most used in all ranking groups were no. 26, 6, 12 and 22 (see Table 3). The most common number of turns was 2 or 3 full rotations, except the "fouettés" (no. 22 and 23), in which the gymnasts intended to complete more than 4 turns.

BD in Series: The ranking groups showed a similar number (p=0.205) and value (p=0.279) of BD in series. The series were performed only in jump elements: no. 18, 20 and 21 (see Table 1). However, the jumps most used in the series were no. 18 and 20 in all groups. Jump no. 21 was only used in series by the 3rd group (0.9%).

Multiple Rotation Difficulties: 54.7% of finalists' routines, 24.1% and 32.1% of the routines of the 2nd and 3rd groups, respectively, incorporated at least one multiple difficulty. Therefore, significant differences were found in the number of multiple difficulties in the finalists versus the 2nd (p<0.001) and 3rd (p=0.017) groups.

Mixed Difficulties: The combinations in mixed difficulties most used were balance plus balance, rotation plus rotation and rotation plus balance. Most gymnasts that

presented mixed difficulties only had one combination of elements. The finalists showed a higher number of routines with at least one mixed difficulty (42.2%). Significant differences were found in the total number of mixed difficulties in the routines of finalists and 2nd group versus the 3rd group ($p \leq 0.05$).

Bonus in BD Elements

BD (Balance elements) Performed with "Slow turn": The finalists did not incorporate BD performed in "slow turn", however, the 2nd (0.9%) and 3rd (2.7%) groups included balance elements no. 14 and 16 (see Table 2) performed on flat foot and in "slow turn".

Criteria Associated with BD (body waves or pre-acrobatic elements): A similar number of routines in all ranking groups presented one or more BD combined with whole body waves (53.1% in the finalists, 57.1% in the 2nd group and 48.2% in the 3rd group). On the other hand, the 2nd and 3rd groups showed a higher number of BD combined with pre-acrobatic elements than the finalists: 51.6% in the finalists' routines and 68.8% in the routines of both the 2nd and 3rd groups (Figure 9).

According to Figure 9, balance elements and jump elements were the body groups most and least used respectively in combination with whole body waves and pre-acrobatics elements. We can see that only the 3rd group had jump elements in combination with whole body waves (0.9%) and the finalists did not incorporate jumps combined with body waves or pre-acrobatic elements.

Significant differences were found in the combination of rotation elements with whole body waves in the finalists versus the 3rd group ($p=0.034$). Furthermore, significant differences were also found in the total number of BD and balance elements combined with pre-acrobatic elements in routines of finalists versus the 2nd and 3rd groups ($p \leq 0.05$).

Thus, we observed that the higher the ranking position, the lower the number of pre-acrobatic elements combined with all variables analyzed (jumps, balance elements, rotations and total BD elements).

In addition, we verified that in 92.1% of the routines, balance element no. 16 (see Table 2) was performed in combination with a pre-acrobatic element.

BD Values: Table 5 shows that significant differences were found in rotation values in the finalists and 2nd group versus the 3rd group. The routines with a lower ranking position had lower rotation values.

Significant differences were also found when comparing body group values: rotations versus jumps ($p<0.001$) and balance elements ($p<0.001$) in all ranking groups. The rotations had higher values than jumps and balance elements (Table 5).

Table 6 displays that the jump elements with values above 0.50 points were most used by the finalists and 2nd group, while the 3rd group presented more jump elements with 0.50, 0.40 and 0.30 points than the other ranking groups. Significant differences were verified in the finalists versus the 3rd group in jumps with 0.40 points ($p=0.040$) and jumps above 0.50 points ($p=0.029$).

No significant differences were verified between the ranking groups in balance element values. The balance elements presented a lower value range, from 0.30 to 0.50 points. The balance elements of 0.50 points were used in the routines in all ranking groups and the 3rd group used more balance element values of 0.40 and 0.30 points than the other groups.

All ranking groups had a higher number of rotations of 0.30 points (Table 6). Furthermore, the 3rd group showed a lower number of rotations of 0.30 points and a higher number of rotations of 0.10 points than the other groups. Thus, significant differences were found in the finalists and 2nd group versus the 3rd group ($p \leq 0.05$) in rotation values of 0.30 and 0.10 points.

The Importance of Variables Analyzed in Ranking Position: According to multiple regression, the regression coefficient of variables: total jumps, balance elements, rotations, mixed difficulty values and

number of difficulties with whole body wave presented statistical significance, and therefore, explains 16.7% of the gymnasts' difficulty final score in the 2013 and 2014 Lisbon World Cup ($F = 12.008$, $p<0.001$, $R^2 = 0.182$, R adjusted square = 0.167). The regression equation is: Difficulty final score = 5.09 + 0.583 (total jump values) + 0.302 (total balance element values) + 0.377 (total rotation values) + 0.417 (total mixed difficulty values) – 0.101 (number of difficulties with whole body wave).

According to the standardized coefficients (Beta) presented in the multiple regression, the relative degree of importance of variables in gymnasts' final score in ascending order is as follows: balance element values (0.137); mixed difficulty values (0.302); jump values (0.295) and rotation values (0.342).

DISCUSSION

Body Difficulties: The RG-CoP (FIG, 2012) included 150 BD in different levels. The distribution of these BD were as follows: 50 in jump elements, 54 in balance elements, 46 in rotation elements. In the jumps, including possible additional criteria (ring, back bend, rotation of 180º or more, passing with bent or straight legs in split), we observed about 107 different possibilities of jump shapes.

According to the analysis of the number and proportion of the BD used in the routines, 54.4% of routines had predominance of rotations, while only 12.2% and 11.5% had a higher number of jump and balance elements, respectively. In addition, in 21.9% of the routines, there was a balance in the number of elements of the three body groups: 3 BD from each body group. We verified 25 variations of jumps (23.4%), 21 variations of balance elements (38.9%) and 27 variations of rotations (58.7%). Therefore, when the BD were compared based on the number of usage, it was observed that the rotations were the most used elements while balance elements were the least used. When the elements were compared based on the variations of BD, it was determined that the most variations were in rotation elements and the least variations were in jump elements.

Thus, the analysis according to the type of BD showed us similar results as Leandro, Ávila-Carvalho, Sierra-Palmeiro, and Bobo-Arce (2016b) for routines performed at the Olympic cycle 2013-2016. The authors found that the rotation elements (especially pivots) were the preferred by gymnasts and the balance elements were the least used, although we observed that the gymnasts with a lower ranking position had lower rotation values, probably because these are very complex elements (Vitrichenko, Klentrou, Gorbulina, Della Chiaie, & Fink, 2011). The preference of the rotations in the routines can be explained by the high possibility that the gymnast can get more points in a single difficulty. According to the RG-CoP (FIG, 2012), each additional rotation on relevé of 360º increases the level of the rotation difficulty by the base value. And each additional rotation of 360º on flat foot or another part of the body increases the level of difficulty by 0.20 point. Furthermore, there is the possibility to execute multiples rotation difficulties (pivots): a connection of 2 or more pivots with different shapes and all pivots performed count as 1 difficulty (FIG, 2012). On the other hand, for Leandro, Ávila-Carvalho, Sierra-Palmeiro, and Bobo-Arce (2016a), the rotation elements are among the main types of difficulty elements responsible for the difference between the initial and final difficulty score in the routines. For the authors, these results suggest that the judges and coaches do not have the same perception of the evaluation criteria of these elements.

The low number of balance elements used in the routines was probably due to the fact that they are static elements with slow execution (Gateva et al., 2015) and especially because they do not have additional criteria to increase the base value, and 0.50 points is the maximum possible value for a balance element (FIG, 2012). Although jump elements have additional criteria to increase their base value, these

elements cannot achieve the same values of rotation elements in routines; this explains the higher total number of rotations versus jumps.

In previous several studies, the jump elements were reported as the most used difficulties in routines in RG (Ávila-Carvalho, Leandro, & Lebre, 2011; Ávila-Carvalho, Palomero, & Lebre, 2009; Caburrasi & Santana, 2003; Salvador, 2009). Ávila-Carvalho et al. (2012) observed that the balance elements and jumps were, respectively, the first and second mostly used body groups in all ranking position composition routines. As the authors analyzed group routines (5 gymnasts), the rotation elements were least used probably because these are the most complex and time dependent BD. This makes them more unpredictable when trying to demonstrate a good synchronization amongst five gymnasts (Ávila-Carvalho et al., 2012).

We observed, like Leandro et al. (2016b), a limited variety in the use of BD elements. In our study, only 6 jumps (5.6%), 8 balance elements (14.8%) and 9 rotation elements (33.3%) were mostly used, in at least 10% of the routines, although the RG-CoP has a great variety of BD elements to be used.

The success in RG is achieved with high level and perfect execution of body elements and apparatus technique, in harmony with the character and rhythm of the music, respecting the principle of originality and diversity (Massidda & Calò, 2012). The limited variety on BD elements is a negative point, because it makes the composition uninteresting and it does not favor the artistic value (Ávila-Carvalho et al., 2012). Furthermore, the composition does not become unique, with the expected diversity and creativity for a spectacular routine (Balcells, Martín, & Anguera, 2009; Leandro et al., 2015). As RG is a visually appealing sport, it is very important to keep the high interest of the public (Agopyan, 2014), and the judges. On the other hand, to achieve perfection and reproducibility of their routines, the gymnasts must practice and repeat the basic elements countless times (Hutchinson, 1999). Therefore, this may explain the reduced variety of BD in the routines. To attain better performances, without execution faults, the gymnasts tend to use the same quality BD for all of their routines and it is clearly an indication of the lack of selection of the BD (Agopyan, 2014).

Jump Difficulties: The jump elements most used were "jeté with turn", which contain the highest values in the RG-CoP (FIG, 2012). These types of jumps with rotation provide a greater variety of movements and thus contribute to the originality of the routine (Breitkreutz & Hökelmann, 2014). However, these are more demanding on the gymnasts' physical preparation, requiring a higher level in body training (E. Lebre & Araujo, 2006) and in apparatus handling, because it is harder to perform with apparatus work (Ávila-Carvalho et al., 2012). The easy jump elements are mostly linked with complex apparatus technique (Breitkreutz & Hökelmann, 2014).

Trifunov and Dobrijević (2013) analyzed the routines of the 6 best gymnasts in the 2010 World Championship in Moscow and they observed that the most used jumps in hoop, ball and rope routines were no. 15, 20, 18, 16 and 9 (see Table 1). Therefore, jumps no. 15, 20 and 18 continue to be widely used by the best ranked gymnasts. Jumps no. 16 and 9 are not being used with the same frequency by gymnasts, probably because they have less additional criteria to increase the routine score. These same elements with additional criteria were amongst the jumps most used by the finalists: no. 17 and 21 (see Table 1). Agopyan (2014) also observed that the elite gymnasts displayed a wider variety of "jeté with turn" jumps in all apparatus analyzed: no. 15, 16, 18 and 20.

In our study, the higher the ranking position, the higher the jump values used in routines. The same results were verified by Leandro et al. (2016b). The finalists and 2nd group incorporate the jump elements with the highest values (> 0.50 points). These

elements have a high level of physical and technical demand (E. Lebre & Araujo, 2006). On the other hand, the lower the ranking position, the higher the usage of jump elements with low values, which confirms the expected result, although the 3rd group preferred jumps with 0.50 points.

The gymnasts presented only series in jump elements: no. 18, 20 and 21 (see Table 1). We verified that only turning split leaps with values equal to or higher than 0.50 were performed in series in the routines. Series are an exception in the RG-CoP (FIG, 2012), because the gymnasts can perform two or more successive identical jumps with or without an intermediary step (depending on the type of jump). Each jump element in a series is assessed as a difficulty; therefore, the gymnasts choose jumps with a higher value and more beauty. These turning split leaps used in series are performed with body rotation and a high range of motion, which ensures more beauty in the routine.

Balance Elements Difficulties: The most commonly used balance elements in hoop, ball and rope routines by the 6 best gymnasts in the 2010 World Championship in Moscow were no. 9, 10, 13, 15, 16 and 18 (see Table 2) (Trifunov & Dobrijević, 2013). Therefore, balance elements no. 10, 13, 15 and 16 continue to be widely used by the best gymnasts in their routines. Balance element no. 9 is not used with the same frequency by gymnasts, probably because in the RG-CoP (FIG, 2012) this element has a high difficulty level and it is less valued than in the previous RG-CoP (FIG, 2009). According to our analysis, balance element no. 18 was most used by the 2nd and 3rd groups when compared to the finalists. For Agopyan (2014), the balance elements most used by elite gymnasts were no. 13, 15, 16, 3 and 18 (see Table 2). Only balance element no. 18 has dropped from the elements most used by elite gymnasts, probably because this balance element requires a lot of time to be executed, since the gymnasts have to show all the different shapes of this element (FIG, 2012).

The ranking groups included mostly balance elements with 0.50 points. However, as expected, and also verified by Leandro et al. (2016b), the gymnasts of lower ranking had a higher number of 0.30 and 0.40 points balance elements. In our study, the finalists presented more balance elements with high amplitude requirements than the 2nd and 3rd groups. If gymnasts want to compete for a higher place in the ranking, they must include balance elements of higher amplitude and value in their routines (Ávila-Carvalho et al., 2012). The flexibility is the main physical quality required for the execution of most RG technical elements (Laffranchi, 2005), since RG is characterized by high amplitude and plasticity movement (Bobo & Sierra, 1998).

Finalists did not incorporate BD performed in “slow turn” as per another recent study (Agopyan, 2014). The "slow turn" was not frequently used in routines probably due to its high difficulty demand (in relevé), and especially because it requires more time to complete the element.

Specific balance elements can be performed on flat foot; however, the value is reduced by 0.10 point (FIG, 2012). The use of balance elements on flat foot can be justified by an easier and more stable execution. We observed a higher number of routines with balance elements on flat foot in the 2nd (23.2%) and 3rd (11.6%) groups. The finalists were the group with the lowest number of balance elements on flat foot (9.4%). Most BD executed on flat foot were performed in mixed difficulties (46.7%) or in combination with body wave and/or pre-acrobatic elements (42.2%).

Rotation Difficulties: The rotation element most used was the “Penché” (no. 26) (see Table 3), as Agopyan (2014) also observed in elite gymnasts in the 2012 London Olympic Games, although this element was part of Flexibility/body waves difficulty elements. The new technical framework (FIG, 2012) eliminated this body group and these elements became balance difficulty elements or rotation difficulty elements. In our study, 80.2% of the routines showed rotation no. 26. This rotation requires the trunk bending forward and the leg position at 180 degrees

backwards. This element is not the most demanding element, compared to other elements with the same difficulty value, which might be the reason why it is used so often (Agopyan, 2014). Furthermore, the gymnast can execute a high number of turns probably because it is performed in flat foot, and it is possible to get higher control and stability. Each additional turn of 360º on flat foot or another part of the body increases the difficulty level by 0.20 point (FIG, 2012).

According to Agopyan (2014), the rotations most used by elite gymnasts were no. 6, 12, 22 and 23 (see Table 3). The fouetté rotations (no. 22 and 23) were the BD with the highest value. In another study, Trifunov and Dobrijević (2013) observed the most common rotation elements used in hoop (no. 6, 11, 12, 13, 15, 18, 19 and 26), ball (no. 11, 12, 13, 15, 18, 19 and 21) and rope (no. 6, 7, 8, 12, 13 and 15) routines (see Table 3). They concluded that rotations no. 12 and 13 were the most used in all routines. Rotations no. 6, 12 and 26 continue to be widely used by the best gymnasts in their routines probably because they perform many turns in these elements and, therefore, can achieve high BD values. Rotation no. 18 was also one of the most used by finalists although we believe that this BD was used in their routines due to its high base value, as the gymnasts perform a limited number of turns in this element. Previous studies (Ávila-Carvalho et al., 2011; E. Lebre, 2007; Salvador, 2009) verified that the "fouetté" pivot (no. 22 and 23) was not the most used in individual routines.

However, these BD are currently widely used in routines of gymnasts in all ranking positions. "Fouetté" pivots (no. 22 and 23) had a higher number of turns than the remaining rotation elements because they allow the gymnast to descend from relevé in-between turns, making it easier to achieve a higher number of turns. Rotations no. 7, 11 and 19 are not being used with the same frequency by gymnasts probably because these elements have a high difficulty level and it is difficult to perform a high number of turns. Rotations no. 8, 15 and 21 were not used by the finalists. Rotation no. 21 was widely used in the RG-CoP 2009-2012 (FIG, 2009), but in the RG-CoP 2013-2016 (FIG, 2012) this element saw its base value highly reduced, so its use was also reduced.

We observed that 59.3% of rotation elements used in the competition were among the rotations least used and not used by finalists in their routines. This non-preference for some of these rotations can be justified by the high complexity of the elements and consequent limited possible number of turns. The non-preference for the other rotations can be justified by their initial low score or by the lack of beauty in the shape. Rotations no. 2, 3, 10 and 21 (see Table 3) were used by finalists only in multiples difficulties.

Only the 3rd group incorporated rotations from the group "Rotation on various parts of the body" (no. 27) (see Table 3). The finalists and the 2nd group only used pivots, probably because it is possible to achieve a higher score performing a higher number of turns. Each additional turn (360º) on "relevé" increases the difficulty level by the base value (FIG, 2012); therefore, gymnasts in all groups used rotation elements in which they could achieve a higher number of turns.

Multiples rotation difficulties (pivots) are complex elements in which the gymnasts perform 2 or more pivots with different shapes, connected without heel support, and no bonus is given for connection (FIG, 2012). The routines of finalists presented a higher number of multiples difficulties than the remaining groups. The finalists are the best gymnasts, therefore it was expected that they would present more complex rotations than the gymnasts of lower ranking groups.

When we analyzed the value of rotation elements used by the different groups, like Leandro et al. (2016b), we observed that the rotations on "relevé" with 0.30 points were the most performed by all gymnasts regardless of their final ranking position. Furthermore, the 3rd group had a higher

number of rotation elements with 0.10 and 0.40 points, while the finalists preferred to include rotation elements of 0.20 and 0.50 points in their routines.

Mixed Difficulties: Mixed difficulties are complex elements in which the gymnasts perform 2 or more different difficulties from the same or different body groups (each component counts as 1 difficulty), connected according to different criteria depending on the body group, with bonuses given for connections performed without interruptions (FIG, 2012). In our study, the finalists performed a higher number of routines with at least one mixed difficulty (42.2%). These results were expected due to the high demanding factors in the execution of mixed difficulties. The high complexity of this type of difficulty demands extraordinary coordination, perfect control of the apparatus technique and a lot of hours of practice (Vitrichenko et al., 2011), therefore, it is expected that the best gymnasts have the most complex elements in their routines.

Leandro et al. (2016b) also verified that mixed difficulties had higher values in the routines of the gymnasts placed in the 1st part of the ranking and decreased in the routines of the gymnasts placed in the 2nd and 3rd ranking parts.

Criteria Associated with Difficulty – body waves or pre-acrobatic elements: Balance elements and jumps were the body groups most and least used, respectively, in combination with whole body waves and pre-acrobatic elements. We observed that the higher the ranking position, the lower the number of pre-acrobatic elements combined with all variables analyzed (balance elements, rotations and jump elements). The finalists had a lower number of pre-acrobatic elements combined with BD probably because, as the pre-acrobatic elements are already widely used in the DER, these gymnasts have routines with a higher variety of elements choosing to combine BD with body waves. Furthermore, the body waves got bonuses only when combined with BD. Therefore, the finalists showed a higher variety of elements in their routines, as they did not present a large number of pre-acrobatic elements (in DER and combined with BD).

However, according to Leandro et al. (2015), the judges presented high levels of disagreement in the evaluation of the criteria (body waves or pre-acrobatic elements) associated with BD elements.

The Importance of the Variables Analyzed in Ranking Position: The data collection was done through the difficulty forms which are a plan of intentions before the competition. Therefore, the analysis was made considering the correct execution of the body difficulties proposed in the official difficulty, since that the final difficulty score reflects what gymnast performed effectively without mistakes during the competition.

The analysis of body difficulties separately of the other difficulties elements was performed to identify within of different types of body difficulties (jumps, balances and rotations elements) and the criteria of RG-CoP associated to the body difficulties (series, mixed and multiples difficulties; number of turns in the rotations elements; slow turn in balances elements; body waves and pre-acrobatic elements in body difficulties), are more important in the difficulty ranking position. However, if we performed an analysis of all difficulty content of the routines it would be necessary to consider also the other three difficulty elements (dance steps, apparatus mastery and dynamic elements with rotation and throw).

Thus, we verified the following hierarchy of importance of the variables that most contribute to the success in the competition: value of rotations; value of jumps; value of balance elements and value of mixed difficulties. Therefore, the rotation elements presented a higher importance in the routines in RG in the Olympic cycle 2013-2016. These results were probably based on the predominance of rotation elements in the routines and the high number of turns proposed in the official difficulty forms.

CONCLUSIONS

The main focus of the routines' composition was on rotation difficulty elements and in the number of turns. Lower values were verified in balance elements and jump elements performed. Among all BD, the rotations were the body group with the most variety, while jumps had the more limited variety. Gymnasts tend to use the same jump, balance and rotation in all their routines, therefore the lack of variety and the similarity of BD levels in the composition of routines in different apparatus in RG can compromise the originality, beauty and variety of this sport.

Although there were no significant differences in the ranking groups in the total value of BD elements (jumps, balance elements and rotations), with the exception of rotations in the finalists and 2nd ranking group versus the 3rd ranking group, we observed that the finalists presented routines with different characteristics. The routines of different ranking positions had similar initial difficulty scores, however, in the competition; the judges validate or invalidate each one of the elements proposed in the official difficulty form. The higher the number of validated elements and the better the quality of execution in the routine, the better the ranking position.

The hierarchy of importance of the variables that most contribute to the success in the difficulty final score in competition is: value of rotation elements; value of jumps; value of balance elements and value of mixed difficulties. Therefore, the rotation elements presented a higher importance in the routines in RG in the Olympic cycle 2013-2016.

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MORPHOLOGICAL CHARACTERISTICS OF YOUNG FEMALE ARTISTIC GYMNASTS FROM THE CZECH REPUBLIC

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Original article

Abstract

The aim of the study is to analyse the somatic parameters of artistic gymnasts in the pupil competition category and to compare them with the values of the general population in the corresponding age group. The study included 16 female gymnasts in the pupil category and 652 girls in the same age group, which formed the control group. Body height was measured using a stadiometer InBody BSM 370, body mass and body composition by BIA analyser InBody 770 (Biospace, South Korea). The monitored values of each gymnast we compared with the mean values of the control group at the corresponding age separately, using the normalisation index (Ni). The results of the study show that the gymnasts in the youngest competition category already differ in basic anthropometric parameters from the general population. Since the age of nine, the gymnasts have a lower body height (except for one person) and lower body weight than the girls in the general population. The body height and body mass values are below average or highly below average in nine gymnasts (56.3%). The high volume of specific physical activity of the gymnasts, included in their training, affects their body composition parameters. The gymnasts have lower body fat (%) and visceral fat (cm2), their values are below average to highly below average, and higher skeletal muscle mass (%), with values above average or highly above average.

Keywords: *artistic gymnastics, youth, female, morphology.*

INTRODUCTION

In artistic gymnastics, achieving the highest performance level requires a significant development of motor abilities, skills and an overall high-level development of physical fitness. That is also related to the precondition of optimal development of somatic parameters that represent a significant determinant of each sport performance (Schnabel, Haare, & Krug, 2008). Gymnastics requires explosive sprinting, jumping, pushing and pulling skills, together with balance and artistry on four apparatus for women (beam, uneven bars, floor, vault) (Bradshaw & Hume, 2012). These gymnastic elements lay demands on the strength of the corresponding muscle groups and on the coordination of the muscle activity in space and time.

The intensity of the gymnastic elements requires a long-lasting preparation of gymnasts that starts at an early age, at the

end of the period of the first infancy (Infans I), as confirmed by the experience of gymnastic clubs where girls start training at the age of 4. Bradshaw and Hume (2012) stated that women's artistic gymnastics attracts a large number of children with participation often beginning at five years of age. According to the rules of competition of the Czech Gymnastic Federation, the youngest age group are pupils. This category is defined as ages from 7 to 12 and it thus includes the beginning of the second infancy (Infans II). Previous studies have shown that gymnastics training has numerous health benefits such as bone mineral accrual advantage and reduced risk of osteoporosis (Zanker, Osborne, Cooke, Oldroyd, & Truscott, 2004), enhanced fine postural control (Vuillermea et al., 2001), and increased core strength (Scerpella Davenport, Morganti, Kanaley, & Johnson, 2003). However, the combination of the young age of the gymnasts, and the high volume of physical training that increases throughout the competitive levels, could increase the potential of injuries (Daly, Bass, & Finch 2001).

The intensity of the gymnastic elements together with the specific long-term preparation has to have an effect on the morphological parameters of both male and female gymnasts. This is also confirmed by the incorporation of such parameters into the structure of the performance in gymnastics (Bale & Goodway, 1990). These authors stated that elite female gymnasts are generally short, light, and have excellent strength, power, flexibility and agility. Moreover, it has been suggested that successful young gymnasts are part of a highly select group in terms of specialized motor skills, body size and shape (Baxter-Jones, Thompson, & Malina, 2002). Thus, a question arises: whether or not gymnasts in the youngest competition age group differ morphologically from general population. The results of several studies confirm that the somatic parameters of athletes in various sports do not only differ between the individual disciplines, but also from the values of the general population (Dostálová, Přidalová, & Kudrna, 2005; Gil, Gil, Ruiz, Irazusta, & Irazusta, 2007; Özçakar, Cetin, Kunduracýo, & Ülkar, 2003; Sánchez-Muñoz, Sanz, & Zabala, 2007). Moreover, these differences increase with age and time spent in specific training process (Kutáč, 2012; Norton & Olds, 2001). These parameters are usually consisted from body height, body mass, body mass index, % body fat, skeletal muscle mass and/or skinfold thicknesses measures to determine an anthropometric profile of athletes.

Therefore, the aim of the study is to analyse the somatic parameters of artistic gymnasts in the pupil competition category and to compare them with the values of the general population in the corresponding age group. The current research may provide information about the talent selection in artistic gymnastics, and whether specific gymnastic training affects the morphology of young female gymnasts when compared with the normal population of the same age; and to determine an anthropometric profile of talented young female gymnasts.

METHODS

The study included 16 female gymnasts (8-12 years) in the pupil category and 652 girls in the same age group, which formed the control group (CG). All gymnasts had more than five years of experience with systematic training and competitive gymnastics. Their training volumes were 5 ± 0.8 training days per week and 3.7 ± 0.5 training hours per day. Informed consent and parental consent were obtained from each gymnast and their parents, respectively, in accordance with the guidelines of the Institute's Ethics and Research Committee. The girls in the control group were healthy individuals without any medical problems that did not do any regular organised physical activity. The precise numbers in the individual age categories and groups are presented in Table 1. The classification into the corresponding age category was executed according to WHO. An individual is included in the age group after exceeding the chronological age

within the range of a year (e.g. 11 years old = 11.00–11.99 years old) (Vignerová, Lhotská, Bláha, & Roth, 1996).

Table 1
Frequency of participants in age categories.

Age (years)	Gymnasts (n)	Control group (n)
8	2	149
9	3	152
10	4	148
11	5	105
12	2	98

n – frequency

The basic parameters of body height (BH) and body mass (BM) were measured in all participants and these were used to calculate the body mass index (BMI). Out of the body composition parameters, the following were measured: body fat (BF), total body water (TBW), fat free mass (FFM), skeletal muscle mass (SMM) and visceral fat (VFA). Body height was measured using a stadiometer InBody BSM 370 (Biospace, South Korea), body mass and body composition by BIA analyser InBody 770 (Biospace, South Korea) (Figure 1). The InBody 770 analyser is a tetrapolar multi-frequency bioimpedance analyser using a frequency of 1 000 kHz; this instrument was simultaneously used as a scale. BMI calculation:

$$\text{BMI} = \frac{BM\ (kg)}{BH^2\ (m)} \qquad (1)$$

Figure 1. Measurement technology.

With regard to the range of the age distribution of the group of gymnasts, it is not possible to assess the gymnasts as one group and therefore we determined the mean age. Their frequency in the individual age groups, however, does not allow for the use of the method of descriptive statistics. Therefore, we compared the monitored values of each gymnast with the mean values of the control group at the corresponding age separately, using the normalisation index (Ni). Ni calculation:

$$\text{Ni} = \frac{X-M}{SD} \qquad (2)$$

Legend: X – gymnast's value, M – mean control group, SD – standard deviation control group.

The Ni value in the range of ±0.75 SD shows an average development of the indicator, in the range from ±0.76 to 1.5 SD a below average (above average) development of the indicator and the value above ±1.5 SD means a highly below average (above average) development.

RESULTS

The results present the comparison of the mean values of the basic anthropometric parameters of our control group with the values of the 6th Nation-wide Anthropological Survey of Children and Adolescents (Bláha & Vignerová, 2006) (Table 2), the found values of the morphological parameters of the monitored gymnasts (Table 3), and comparison of their values with the values of the control group (Table 4).

Table 2
Comparison of basic anthropological parameters of the control group with 6th Nation-wide Anthropological Survey of Children and Adolescents.

Years		BH (cm)	BM (kg)	BMI (kg/m^2)
8	M±SD (6th NAS)	132.8±6.1	29.5±5.6	16.6±2.4
	Ni CG	-0.01 SD	-0.05 SD	-0.05 SD
9	M±SD (6th NAS)	138.4±6.4	32.7±6.7	17.0±2.6
	Ni CG	-0.16 SD	-0.13 SD	- 0.07 SD
10	M±SD (6th NAS)	144.6±7.1	37.3±7.9	17.7±2.8
	Ni CG	-0.10 SD	-0.02 SD	0.03 SD
11	M±SD (6th NAS)	151.0±7.6	41.8±9.1	18.2±3.0
	Ni CG	-0.16 SD	-0.07 SD	-0.01 SD
12	M±SD (6th NAS)	157.6±7.3	47.1±9.1	18.9±3.0
	Ni CG	0.25 SD	0.27 SD	0.14 SD

Legend: M – mean, SD – standard deviation, 6th.NAS - national anthropological research, BH – body height, BM – body mass, BMI – body mass index

Our control group can be considered to be a generally healthy Czech population in basic anthropometric parameters. The values we measured can be labelled as average in all monitored age categories. The comparison of their Ni values with the values of 6th NAS did not exceed the level of ±0.75 SD.

The BH values range from above average (Ni > 0.75 SD) in one eight-year-old gymnast to highly below average (Ni < -1.5 SD) in one eleven-year-old gymnast. The BM values also correspond with the BH values, ranging from average values to below average values. The eleven-year-old gymnast with a highly below-average value is an exception (Ni = -1.55 SD). The BMI values calculated from the BH and BM values are average with regard to the control group values, the Ni values range from -0.61 SD to +0.59 SD. The exception includes two eleven-year-olds and one twelve-year-old gymnast. Their values show a below-average to highly below-average BM with regard to their BH (Ni BMI = -0.85 to -1.61 SD). Organism hydration of most gymnasts was average. Their TBW values corresponded with the average values found in the control groups (Ni = ± 0.75 SD). The TBW value was lower only in three gymnasts (Ni = - 0.77 to -1.09 SD) and higher in three gymnasts (Ni = 0.86 to 1.67 SD).

The BF ratio in kilograms was lower in all gymnasts than in the control group. The value was below average in fourteen gymnasts (Ni ranging from -0.84 to -1.28 SD) and highly below average in two gymnasts (Ni < -1.5 SD). When comparing the percentage BF ratio of the gymnasts with the control group, the difference in the BF ratio is more significant. The value is highly below average in twelve gymnasts (Ni < -1.5 SD) and below average in four gymnasts (Ni ranging from -0.93 to -1.46 SD). In addition to body fat (BF), we also measured visceral fat (VFA), which is in the abdominal cavity. The values of this parameter were also lower in gymnasts than in the control group. All the determined values were below average (Ni ranging from -0.90 to -1.49 SD).

A higher ratio of FFM and SMM was only found in three gymnasts. The FFM value was even below average in three gymnasts (Ni ranging from -0.76 to -1.11 SD) and two gymnasts had below-average SMM value in kilograms (Ni = -1.06 SD). The increased SMM ratio in gymnasts was reflected in the comparison of the percentage ratio of SMM to BM. The value was highly above average in fourteen gymnasts (Ni > 1.5 SD) and above average in two gymnasts (Ni > 0.75 SD).

Table 3
Values of the morphological parameters of the gymnasts and the control group.

Groups	BH (cm)	BM (kg)	BMI (kg/m^2)	TBW (l)	BF (kg)	BF (%)	FFM (kg)	SMM (kg)	SMM (%)	VFA (cm^2)
CG8										
M±SD	132.7±5.8	29.2±6.4	16.5±2.9	16.8±2.2	6.4±4.1	20.3±8.8	22.8±6.0	11.5±1.8	39.9±4.0	39.5±22.1
$G8_1$	139.0	29.3	15.2	20.5	1.4	4.8	27.9	14.6	49.83	12.6
$G8_2$	134.5	27.8	15.4	18.9	2.1	7.5	25.7	13.4	48.2	10.0
CG9										
M±SD	137.3±5.8	31.8±6.4	16.8±2.8	18.2±2.2	7.0±4.3	20.7±8.1	24.8±3.0	12.6±1.8	40.3±4.1	39.7±24.3
$G9_1$	127.0	25.3	15.7	17.6	1.5	5.7	23.8	12.5	49.4	7.0
$G9_2$	131.0	26.8	15.6	18.6	1.6	6.0	25.2	13.1	48.9	12.6
$G9_3$	133.0	27.6	15.6	18.9	1.8	6.7	25.8	13.4	48.6	10.0
CG10										
M±SD	143.9±7.1	37.1±8.5	17.8±3.2	20,7±3.0	9.0±5.6	22.6±8.8	28.2±4.0	14.6±2.4	40.1±4.4	46.9±29.0
$G10_1$	143.0	34.0	16.6	23.2	2.4	7.1	31.6	16.9	49.7	7.8
$G10_2$	135.0	30.3	16.5	20.3	2.8	9.1	27.5	14.4	47.5	10.8
$G10_3$	143.0	32.8	16.0	21.7	3.2	9.7	29.6	15.6	47.6	11.6
$G10_4$	138.0	31.2	16.4	19.8	4.3	13.7	26.9	13.8	44.2	20.7
CG11										
M±SD	149.8±7.4	41.1±9.4	18.2±3.0	23.19±3.7	9.6±5.7	22.1±7.9	31.5±5.1	16.5±3.0	40.7±4.1	48.9±29.2
$G11_1$	140.5	32.4	16.4	20.2	4.8	14.8	27.6	14.3	44.1	19.1
$G11_2$	136.5	31.6	17.0	21.2	2.8	9.0	28.8	15.2	48.1	9.0
$G11_3$	150.0	36.7	16.3	24.7	3.1	8.6	33.6	18.2	49.6	5.4
$G11_4$	135.0	28.5	15.6	19.0	2.6	9.0	25.9	13.5	47.4	8.6
$G11_5$	141.5	26.6	13.3	19.0	0.8	3.0	25.8	13.5	50.8	13.8
CG12										
M±SD	159.4±8.1	49.6±11.5	19.3±3.3	28.4±4.8	10.8±6.1	20.5±7.2	38.8±6.5	20.8±3.9	42.5±3.6	47.4±28.0
$G12_1$	148.5	38.6	17.5	26.9	2.2	5.7	36.4	19.7	51.0	10.3
$G12_2$	160.0	40.7	15.9	29.0	1.2	3.0	39.5	21.6	53.1	9.2

Legend: CG – control group, G8 – 8 gymnasts years old, G9 – 9 gymnasts years old, G10 – gymnasts 10 years old, G11 - 11 gymnasts years old, G12 - gymnasts 12 years old, BH – body height, BM – body mass, BMI – body mass index, TBW – total body water, BF – body fat, FFM – fat free mass, SMM – skeletal muscle mass, VFA – visceral fat.

Table 4
Values of normalisation indexes (Ni) of the morphological parameters of the gymnasts.

Gymnasts	BH (cm)	BM (kg)	BMI (kg/m2)	TBW (l)	BF (kg)	BF (%)	FFM (kg)	SMM (kg)	SMMp (%)	VFA (cm2)
G81	1.09 SD*	0.01 SD	-0.45 SD	1.67 SD**	-1.23 SD*	-1.77 SD**	1.67 SD**	1.72 SD**	2.47 SD**	-1.21 SD*
G82	0.31 SD	-0.22 SD	-0.38 SD	0.96 SD*	-1.05 SD*	-1.46 SD*	0.95 SD*	1.06 SD*	2.06 SD**	-1.33 SD*
G91	-1.77 SD**	-1.01 SD*	-0.39 SD	-0.27 SD	-1.28 SD*	-1.85 SD**	-0.33 SD	-0.08 SD	2.25 SD**	-1.35 SD*
G92	-1.09 SD*	-0.78 SD*	-0.42 SD	0.17 SD	-1.25 SD*	-1.81 SD**	0.13 SD	0.25 SD	2.12 SD**	-1.12 SD*
G93	-0.74 SD	-0.65 SD	-0.42 SD	0.31 SD	-1.21 SD*	-1.73 SD**	0.33 SD	0.42 SD	2.04 SD**	-1.22 SD*
G101	-0.12 SD	-0.37 SD	-0.38 SD	0.86 SD*	-1.18 SD*	-1.76 SD**	0.85 SD*	0.96 SD*	2.21 SD**	-1.35 SD*
G102	-1.18 SD*	-0.81 SD*	-0.41 SD	-0.13 SD	-1.11 SD*	-1.53 SD**	-0.17 SD	-0.09 SD	1.71 SD**	-1.24 SD*
G103	-0.12 SD	-0.51 SD	-0.57 SD	0.35 SD	-1.04 SD*	-1.46 SD*	0.36 SD	0.41 SD	1.72 SD**	-1.22 SD*
G104	-0.83 SD*	-0.70 SD	-0.44 SD	-0.30 SD	-0.84 SD*	-1.01 SD*	-0.31 SD	-0.35 SD	0.95 SD*	-0.90 SD*
G111	-1.26 SD*	-0.93 SD*	-0.59 SD	-0.77 SD*	-0.85 SD*	-0.93 SD*	-0.76 SD*	-0.74 SD	0.83 SD*	-1.02 SD*
G112	-1.80 SD**	-1.02 SD*	-0.39 SD	-0.51 SD	-1.20 SD*	-1.66 SD**	-0.53 SD	-0.44 SD	1.80 SD**	-1.37 SD*
G113	0.03 SD	-0.47 SD	-0.62 SD	0.43 SD	-1.14 SD*	-1.71 SD**	0.41 SD	0.56 SD	2.17 SD**	-1.49 SD*
G114	-2.00 SD**	-1.35 SD*	-0.85 SD*	-1.09 SD*	-1.23 SD*	-1.66 SD**	-1.09 SD*	-1.00 SD*	1.62 SD**	-1.38 SD*
G115	-1.12 SD*	-1.55 SD**	-1.61 SD**	-1.09 SD*	-1.55 SD**	-2.41 SD**	-1.11 SD*	-1.00 SD*	2.45 SD**	-1.20 SD*
G121	-1.35 SD*	-0.96 SD*	-0.56 SD	-0.31 SD	-1.41 SD*	-2.05 SD**	-0.37 SD	-0.29 SD	2.33 SD**	-1.32 SD*
G122	0.07 SD	-0.78 SD*	-1.05 SD*	0.13 SD	-1.58 SD**	-2.42 SD**	0.10 SD	0.19 SD	2.89 SD**	-1.36 SD*

Legend: G8 – 8 gymnasts years old, G9 – 9 gymnasts years old, G10 – gymnasts 10 years old, G11 - 11 gymnasts years old, G12 - gymnasts 12 years old, BH – body height, BM – body mass, BMI – body mass index, TBW – total body water, BF – body fat, FFM – fat free mass, SMM – skeletal muscle mass, VFA – visceral fat, * Ni = ±0.76 to 1.5 SD, ** Ni = above ±1.5 SD.

DISCUSSION

The BH of gymnasts aged 9 and above is lower than the mean values of the control group, except for one twelve-year-old gymnast. Even though the differences are not of the same significance for all the gymnasts, they confirm the results of other authors who state in their studies that child and adolescent gymnasts are at the level of P10 – <P50 in the percentile growth chart of reference data for the corresponding age group (Malina, 1994; Malina, 1998), which represented a lower to low BH. Also, the peak height velocity (PHV) of the gymnasts was found at a later age. PHV of gymnasts is stated at the age of 13.2±0.7 and of other physically active girls at the age from 11.8±0.9 to 12.3±0.8, of not physically active girls at the age of 11.4-12.2 (Malina, 1999; Malina & Geithner, 2011; Malina, Rogol, Cumming, Coelho e Silva, & Figueiredo, 2015). Although it is possible that small BH and late maturation are due to self-selection for gymnastics (Lindholm Hagenfeldt, & Ringertz, 1994; Peltenburg, Erich, Zonderland, Bernink, Van Den Brande, & Huisveld, 1984; Malina, 1999), it is also possible that growth is retarded as a result of inadequate nutrition for level of activity, particularly during the sensitive phase of pubertal maturation in female gymnasts (Weimann, 2002). With regard to the age of the gymnasts we monitored, it is obvious that they were not in the PHV period yet. However, in spite of that we cannot assume that they would have a future BH comparable with other athletes or general population. Malina, Bouchard and Bar-Or (2004) state that the mean annual increases of gymnasts in the PHV period were 5.6 to 5.8±0.5 cm, which is less than in other athletes or non-active population. The lower BH values also correspond to the low BM values. Like BH, BM is also between P10 - < P50 in the percentile growth chart (Malina, 1994; Malina, 1998). Also, elite adult gymnasts have a lower BM than other athletes (Claessens, Benedict, & Specker, 1991; McArdle, Katch, & Katch, 2007). It has been assumed that the trend toward smaller height and lighter weights in elite female gymnasts may in part be attributed to talent selection based on biomechanical advantages of a pre-pubertal physique that include increased relative strength/weight ratio, greater stability, and decrease moments of inertia (Sands, Borms & Caine, 2003). These parameters have the potential for more complex vaults, increase swing skills on uneven bars, increase stability on the balance beam and also increase take off abilities during floor exercises (Sands, Borms & Caine, 2003).

The gymnasts we monitored can be called proportional individuals as their BMI values were average with regard to the values of the control group, with the exception of three gymnasts. These gymnasts had a significantly lower BM to their BH. The lower BM of the monitored gymnasts is reflected in the lower weight of other tissue (FFM, SMM), which leads to smaller differences in these parameters, expressed in kilograms, between the gymnasts and the control group. The values of the FFM and SMM ratio (kg) in some gymnasts were even lower than in the control group, in spite of the fact that the gymnasts are individuals with regular physical activity. However, the comparison of the percentage ratio of the individual tissues in the total BM clearly shows a significantly lower BF ratio and higher SMM ratio. Findings from the current study are in accordance with previous studies by Cassell, Benedict and Specker (1996) and Soric, Misigoj-Durakovic, & Pedisic (2008). These authors stated that young female gymnasts have lower % BF when compared to chronologically age–matched non gymnast groups. However, caution in interpretation is necessary since their biological age is also lower (Bacciotti, Baxter-Jones, Gaya, & Maia, 2017). From a performance perspective, low percent body fat is clearly beneficial in gymnastics where the body is propelled against gravity, and thus any non-power producing tissue may result in inefficiencies (Sands, Borms & Caine, 2003). Also, the VFA values representing the area that this fat takes up in

the abdominal cavity are significantly lower than in the control group. These lowered values can be a health benefit, especially at an older age. The increased VFA quantity may be a risk factor of many illnesses. Graphically, the Ni values of the monitored gymnasts in the stated parameters are shown in the Figure 2. All Ni values in SMM exceeded the level of 0.75 SD, all the Ni values in VFA and BF were lower than -0.75 SD. The low BF determined in the monitored gymnasts also corresponds with the results of other authors who deal with young athletes. The authors state lower BF ratio in young female gymnasts, not only when compared with reference data, but also when compared with other athletes in various sport disciplines (Malina, Bouchard, & Bar-Or, 2004; Malina & Geithner, 2011).

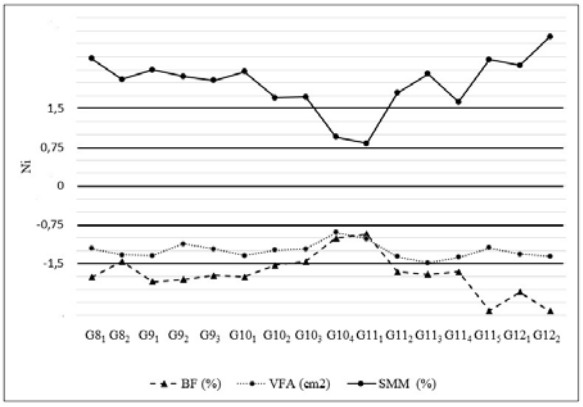

Figure 2. Position of gymnasts according to normal population.

Conclusions from this study must be considered with the sample size in mind and age variability within current sample size of young gymnasts. However, the current study has benefited from the use of gymnasts that are members of talent-selection program in the Czech Republic. In future long-term prospective studies that include morphology components would be useful to clarify specific changes in morphology caused by specific gymnastics training.

CONCLUSIONS

The results of the study show that the gymnasts in the youngest competition category already differ in basic anthropometric parameters from the general population. Since the age of nine, the gymnasts have a lower body height (except for one gymnast) and lower body weight than the girls in the general population. The BH and BM values is below average or highly below average in nine gymnasts (56.3%). The high volume of specific physical activity of the gymnasts, included in their training, affects their body composition parameters. The gymnasts have lower BF (%) and VFA (cm^2), their values are below average to highly below average, and higher SMM (%), with values above average or highly above average.

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BODY PROPORTIONALITY IN ACROBATIC GYMNASTS OF DIFFERENT COMPETITIVE CATEGORIES

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Original article

Abstract

Acrobatic Gymnastics is a gymnastics discipline with a key differentiating element in terms of the role (top and base) played by the gymnasts making up the team. The establishment of the morphological profile is a determining factor as a predictor of sport performance. This study was aimed at establishing the proportional profile based on the proportionality indices of different competitive categories, and determining whether there were differences between them. The study involved 150 Spanish acrobatic gymnasts of both genders, competing nationally and internationally. The measurements were taken following the standards established by the International Society for the Advancement of Kinanthropometry. The different proportionality indices of tops and bases were analyzed, performing the comparative analysis according to the competitive categories of gymnasts. The results showed that among the female tops, there are no significant differences ($p < 0.05$) in the analyzed variables, observing similarities in their proportionality. In all of the categories, both tops and bases have short upper and lower extremities in relation to the classification of these indices. The medium trunk length predominates in all categories except for the men's pair. Most gymnasts have a trunk of an intermediate shape, except in certain cases, when it has a trapezoid shape (tops in women's pairs and bases in men's and mixed pairs). A difference between arm span and height is observed in both tops and bases, according to their competitive category. The results suggest paying attention to these slight differences in body proportionality, in order to guide gymnasts toward a specific competitive category.

Keywords: *acrobatic gymnastics, proportionality indices, competitive category.*

INTRODUCTION

In the world of sport and sport selection, morphological profiles have been one of the most commonly used variables.

These studies have shown that certain anthropometric variables can predict sport performance (Arazi, Faraji, & Mehrtash, 2013; Douda, Toubekis, Avloniti & Tokmakidis, 2008; Kochanowicz, Kochanowicz, Różański & Wilczyńska, 2013; Rodríguez et al., 2014). In addition, Norton, Olds, Olive and Craig (2004) have pointed to body shape and proportionality,

among other factors, as very important variables in determining potential success in certain sports.

In gymnastic sports, this morphological differentiation has also been observed (Bradshaw & Le Rossignol, 2004; Pion et al., 2014). Certain differences between the different specializations within the same discipline have also been referred to by Čuk, Pajek, Jakse, Pajek and Pecek (2012).

Acrobatic Gymnastics (AG) is a gymnastics discipline of the International Gymnastics Federation (FIG), along with Men's Artistic Gymnastics (MAG), Women's Artistic Gymnastics (WAG), Rhythmic Gymnastics (RG), Trampolining (TRA), Aerobic Gymnastics (AER) and Gymnastics for all.

Previously, it was part of the International Federation of Sports Acrobatics (IFSA), and was called Sports Acrobatics. In 1996, IFSA started to merge with FIG, and two years later IFSA dissolved itself. However, it was only later, in 2004, that this discipline was renamed and acquired the name of Acrobatic Gymnastics.

AG is based on rules set out in a Code of Points (CP), specific for each gymnastic discipline. It consists of artificial exercises performed in standardized and stable spaces, involving multiple abilities or independent/autonomous non-natural elements. (Vernetta & López Bedoya, 2005). This discipline is practiced in a specific area of 12 x 12 m, in which the gymnasts perform a combination of individual and group elements in perfect synchronization through choreography (Grapton, Lion, Gauchard, Barrault, & Perrin 2013).

The key element of this sport is its role differentiation played by the gymnasts making up the team. A "base" is the person who holds their partner, and a "top" is the gymnast who performs the elements of balance, flexibility and combinations above the base or large jumps in the air preceded by propulsions of the base, the top landing on the ground or once again on their partner (Vernetta, López Bedoya, & Jiménez, 2007).

The CP (2017) distinguishes between two types of exercises: static, where competitors must demonstrate strength, flexibility, agility, static maintenance, assembles, and movements between one static position and another; and on the other hand, dynamic exercises, in which flight elements predominate.

In the regulatory framework of FIG, five event categories are established, mainly distinguished as groups and pairs with the following combinations:

- Women's Pair (WP). Made up of a top and a base, both women.
- Men's Pair (MP). Made up of a top and a base, both men.
- Mixed Pair (MxP). Made up of a female top and a male base.
- Women's Groups (WG). Made up of a top and two bases, all women.
- Men's Groups (MG). Made up of a top and two bases, all men.

Until a few years ago, there was little scientific evidence on the morphological profile of AG, and it has remained so in terms of proportionality indices (Taboada-Iglesias, Gutiérrez-Sánchez & Vernetta, 2015). However, in other gymnastic disciplines they have been studied, pointing out their importance in order to establish a specific profile. For example, there have been studies which indicated that the index of the relative lower extremity length (RLEL) has proven important as a predictor of WAG performance (Bradshaw & Le Rossignol, 2004). In view of the above, this study is aimed at establishing the proportional profile based on the proportionality indices of different AG categories, and determining whether there are differences between them. Having a profile of proportionality as a reference will facilitate the task of talent detection and sport guidance for coaches and selectors of this gymnastic discipline. So far, there is no scientific evidence to establish the proportionality indices differentiated according to the event categories making up AG. Thus, being the first study that focuses

on this topic, it acquires even greater importance.

METHODS

All subjects participated voluntarily, and given the type of study and the techniques used, this research complied with all the ethical procedures established by the Spanish Organic Law on the Protection of Personal Data (Organic Law 15/1999, of 13 December). Minor subjects' parents signed the informed consent necessary in order to have their measurements taken. The study was approved by the Autonomous Ethics Committee of Research of Xunta de Galicia (Spain) (reference number 2015/672) and was in line with the Declaration of Helsinki.

The sample consisted of 150 Spanish AG national- and international-level gymnasts, selected by intentional non-probabilistic sampling. They were grouped according to their role (top and base) and to the four event categories with sample representation in the present study (Table 1).

All measurements were taken at the same stage of the season. They were carried out by an accredited expert, following the standards established by the International Society for the Advancement of Kinanthropometry (ISAK).

The anthropometric measures taken were: weight with a Tanita digital scale, with precision of 100 g, height (H) and sitting height (SH) by means of a portable stadiometer, arm span, 2 diameters (biacromial and biileocristal), and upper extremity length (UEL), using a Harpenden anthropometer (Holtain). 2 or 3 measurements were performed, making record of the average or median between the obtained values, and making sure at all times that the Technical Error of Measurement (TEM) is not higher than 2% in the rest of measurements.

The weight was taken by placing the subject in the center of the scale with their weight equally distributed between the two feet, wearing a sport outfit (top and shorts).

The height measurement was made using the traction technique by measuring the distance between the vertex and the soles of the feet. The gymnast remained standing, keeping the position for anthropometric measurement, with the heels, buttocks, and back in contact with the vertical plane of the stadiometer. The head was positioned in the Frankfort plane. Gymnast's hands were placed on their jaw, and the subject was pulled up while holding a deep breath.

For the sitting height measurement, the distance between subject's vertex and the ground was measured, while their head was positioned in the Frankfort plane. It was performed using the traction method. The gymnast remained seated on a wooden bench of known height, with the trunk erect forming a 90º angle with the thighs, as well as the articulation of the knees, hands resting on the thighs and feet resting on the ground.

The arm span was measured with the back resting on the wall. It is the distance between the end of the finger tips of the right hand and the left hand when the upper extremities are fully extended and placed at the shoulder height.

The diameters were measured by palpating with the middle fingers the bone relief where the anthropometer branches were placed, exerting a certain pressure with the index fingers on them to reduce the superficial soft tissue.

Starting from these direct measures, the different proportionality indices were calculated: the weight index (WI) ($WI=weight/height^3$), the relative upper extremity length (RUEL= (UEL/H)x100), the relative lower extremity length (RLEL= (LEL/H)x100), the cormic index (CI = (sitting height/height)x100), the skeletal index (SI=[(height - sitting height)/sitting height]x100), the acromio-iliac index (AII= (iliac diameter/acromial diameter)x100) and the relative arm span (RAS=(arm span/height)x100) (Pacheco del Cerro, 1993).

To carry out the statistical analysis, SPSS 22.0 (Statistical Package for the Social Sciences) was employed.

The mean (X) was taken as a measure of central tendency, the standard deviation (SD) as a measure of dispersion, and the Z test of Kolmogorov-Smirnov or the Shapiro-Wilk test for the study of normality. The comparative analysis between groups of the same gender was carried out using the Student's t-test ($p<0.05$) to compare independent measures or Anova of a factor ($p<0.05$) and C Dunnet, and the Mann-Whitney U test or the Kruskal-Wallis test for variables that did not maintain a normal or homogeneous distribution ($p<0.05$).

Table 1
Characteristics of the different study groups.

Group	N	Age		Group	N	Age	
		X	SD			X	SD
Tops	58	11.30	2.97	Bases	92	14.58	2.67
WP Tops	14	11.26	3.65	WP bases	16	14.40	1.65
WG Tops	31	11.58	2.69	WG bases	59	14.48	2.20
MxP Tops	9	9.97	3.22	MxP bases	11	15.24	5.29
MP Tops	4	12.30	1.56	MP bases	6	14.83	2.89

RESULTS

The means, standard deviations and comparative analyses of the proportionality indices of tops in different event categories are shown in Table 2. All of the variables followed a normal distribution except for AII and RAS in the women groups. There is no homogeneity of variance ($p<0.05$) for RLEL, CI and RAS.

The intergroup analysis of the female tops showed there were no significant differences ($p>0.05$) for any of the variables, observing similarities in the proportionality of these gymnasts.

The classification of the variables in these groups presented a RUEL of brachio-brachial morphotype or short upper extremities, just like MP tops. SI classifies WP and MP tops as macro-skeletal or with long lower extremities, whereas WG and MxP tops as mesoskeletal or with intermediate lower extremities. However, RLEL defines all female subjects as brachio-skeletal or with short lower extremities, just like MP tops. Regarding the trunk, CI showed mid-trunk or mesocormic values in all female gymnasts, and short in MP tops. AII indicated that it had a trapezoid shape in WP tops and intermediate in WG and MxP tops, just like in MP tops. On the other hand, RAS indicated that the arm span was slightly lower than the height in WP and MP tops, but higher in WG and MxP tops.

Table 3 shows the means, standard deviations and comparative analyses of the proportionality indices of the bases in different event categories. All variables were normal except for RUEL and RAS. There is homogeneity of variance for all of the proportionality indices ($p> 0.05$).

The RUEL values indicated that they had a brachio-brachial morphotype or with short upper extremities. SI indicated that they had medium-sized lower extremities, whereas RLEL indicated that they were short in both groups. Regarding the trunk values, both groups have a trunk of medium length according to CI, and of an intermediate shape, according to AII. On the other hand, RAS indicated that the arm span was slightly lower than height in WG bases,

but higher in WP bases. However, this difference was not significant either.

Table 4 shows the means, standard deviations and comparative analyses of the proportionality indices of the bases in different event categories. All variables followed a normal distribution, except for RLEL and CI. Levene's test indicated that there was homogeneity of variance for all of the proportionality indices ($p>0.05$), except for SI.

There were no significant differences between the two groups of bases, but slight differences were found in the classification of these variables. Thus, the RUEL values indicated that they had a brachio-brachial morphotype or with short upper extremities. The SI values indicated that MxP bases had long lower extremities, whereas MP bases had medium length lower extremities. However, the RLEL values established that both groups had short lower extremities. Analyzing the trunk, the obtained CI values indicated that MxP bases had one of average length, while MP bases had a long trunk, both groups having a trapezoid trunk, as proven by the AII values. The RAS values showed that both groups presented an arm span larger than height.

Table 2

Descriptive analysis of the proportionality indices of tops and differences between groups of female tops.

	MPT (n=4)		WGT (n=31)		WPT (n=14)		MxPT (n=9)		Levene		One-factor ANOVA	
	X	(SD)	X	(SD)	X	(SD)	X	(SD)		P	F	P
WI	43.99	1.49	43.44	1.64	42.87	2.05	42.67	1.03	2.04	0.141	1.03	0.364
RUEL	42.50	2.21	42.34	1.21	42.08	1.84	42.35	1.62	1.52	0.229	0.16	0.849
RLEL	49.33	1.20	47.06	1.60	47.56	1.69	47.04	.61	5.50	**0.007**	K= 1.09	.579
CI	50.67	1.20	52.94	1.60	52.44	1.69	52.96	.61	5.50	**0.007**	K= 1.09	.579
SI	97.46	4.66	89.07	5.70	90.87	6.15	88.86	2.19	5.50	**0.007**	K= 1.09	.579
AII	70.76	1.69	70.56	6.33	69.65	3.06	72.65	7.55	-	-	K= .99	.609
RAS	99.53	4.41	100.12	2.25	99.09	4.00	100.30	3.10	-	-	K= .65	.723

*(K = Kruskal-Wallis) *p<0.05, **p<0.001.*

Table 3

Descriptive analysis of the proportionality indices of the female bases in WG and WP, and differences between modalities.

	WGB (n=59)		WPB (n=16)		Levene		Student´s	t
	X	(SD)	X	(SD)	F	P	t	P
WI	43.32	1.48	42.71	1.92	1.76	.188	-1.36	.177
RUEL	42.57	1.36	41.67	4.33	-	-	Z=-.13	.897
RLEL	47.29	1.33	46.99	1.82	1.16	.284	-.75	.454
CI	52.71	1.33	53.01	1.82	1.16	.284	.75	.454
SI	89.84	4.77	88.83	6.45	.98	.324	-.69	.492
AII	71.89	4.04	70.34	4.46	.98	.327	-1.33	.187
RAS	99.04	12.05	101.13	2.00	-	-	Z=-1.16	.244

Z= Z-value, Mann-Whitney´s U. *p<0.05, **p<0.001.

Legend: Weight index (WI) / Relative upper extremity length (RUEL) / Relative lower extremity length (RLEL) / Cormic index (CI) / Skeletal index (SI) / Acromio-iliac index (AII) / Relative arm span (RAS).

Table 4
Descriptive analysis of the proportionality indices of the male bases in MxP and MP, and differences between modalities.

	MxPB (n=11)		MPB (n=6)		Levene		Student´s t	
	X	(SD)	X	(SD)	F	P	t	P
WI	42.24	1.70	42.84	2.85	.85	.372	-.55	.594
RUEL	43.17	2.31	43.05	1.68	.07	.788	.11	.910
RLEL	47.58	1.12	46.75	2.39	-	-	Z=-.40	.688
CI	52.42	1.12	53.25	2.39	-	-	Z=-.40	.688
SI	90.86	4.02	88.11	8.30	5.43	**.034**	.76	.472
AII	69.72	4.54	67.55	3.18	.03	.863	1.03	.319
RAS	101.14	2.75	102.52	2.02	.38	.544	-1.07	.302

Z= Z-value, Mann-Whitney´s U. *p<0.05, **p<0.001.

Legend: Weight index (WI) / Relative upper extremity length (RUEL) / Relative lower extremity length (RLEL) / Cormic index (CI) / Skeletal index (SI) / Acromio-iliac index (AII) / Relative arm span (RAS).

DISCUSSION

The influence of proportionality on performance has already been observed in the world of sports and gymnastics for years. The research study carried out by Bradshaw and Le Rossignol (2004) conducted on WAG gymnasts, established that morphology and proportionality were strong predictors of talent in this discipline. The present study also revealed proportional characteristics specific to each group, and despite the fact that differences were not statistically significant, different classifications were established for many variables among them. Therefore, in the small sample studied, certain differentiating characteristics and their possible weight in talent detection or sport guidance could be observed.

If the CI values are taken into account, there are similarities between the female gymnast groups, both tops and bases (WG, WP, MxP), and the WAG and RG gymnasts analyzed by Díaz, Mauri, García and Jiménez (2008), Douda, Laparidis and Tokmakidis (2002), and Douda et al. (2008), all of them being of average dimensions. The MxP male bases were also characterized by a medium trunk, just like the Trampolining gymnasts analyzed by Gómez-Landero (2010). However, MP tops have a short trunk, as shown in other studies conducted on RG (Di Cagno, et al., 2009; Fernández, Vernetta, López-Bedoya & Gómez-Landero, 2006; Vernetta, Fernández, López-Bedoya, Gómez-Landero & Oña 2011). And, finally, the highest dimensions were obtained by MP bases and the gymnasts of the Trampolining National Team, a long trunk being specific in this case. There are also male gymnasts (tops), who obtained lower values, observing a clear differentiation of the role. However, this differentiation is not observed by Taboada-Iglesias et al. (2015), who classified all AG gymnasts as mesocormic or with an intermediate trunk, both in tops and bases, not being able to establish this variable as a predictor of the role. This may be due to the non-differentiation of the sample into event or gender categories.

The shape of the trunk was analyzed through AII. We found similarities between the tops and bases in the groups made up of women, (WG, MxP, WP) and WAG gymnasts (Díaz et al., 2008). They are classified as having a trunk of an intermediate shape, just like the MP tops. AG gymnasts analyzed by Taboada-Iglesias

et al. (2015), also presented the same intermediate shape, confirming it as the most representative shape in this discipline. However, not all of the event categories were the same, since certain groups presented a trapezoid shape of the trunk. The only group of women that were characterized by a trapezoid shape of the trunk were the WP tops, as in RG (Fernández et al., 2006, Vernetta, et al., 2011) and Trampolining (Gómez-Landero et al., 2004; Gómez-Landero, 2010), and in all groups of male bases.

In terms of length of the lower extremities, the two proportionality indices that have been used in previous anthropometric studies were considered, SI and the RLEL, with different classifications. The SI values classified as macroskeletal or with long lower extremities only the WP and MP tops, and the MxP bases. These dimensions were also found in RG gymnasts (Fernández et al., 2006, Vernetta et al., 2011) and WAG specialized in floor exercises (Bester & Coetzee, 2010). However, the rest of the groups, WG tops, MxP tops, WG bases, WP bases, and MP bases, obtained SI values which classified them as mesoskeletal or with intermediate lower extremities, establishing similarities with the Trampolining National Team (Gómez-Landero et al., 2004), also classified as intermediate.

The other index referring to the length of the lower extremities, RLEL, unlike SI, showed that all of the groups had greater similarities with the WAG gymnasts studied by Díaz et al. (2008) and with the gymnasts of the Trampolining National Team analyzed by Gómez-Landero et al. (2004) than with the female RG gymnasts established by SI.

The RUEL values did not differentiate between event groups either. Similar to the differentiation by roles performed by Taboada-Iglesias et al. (2015), in all of the groups it was indicated that AG gymnasts had short upper extremities or a brachio-brachial morphotype. The short extremities of these gymnasts resemble those of the Trampolining gymnasts (Gómez-Landero et al. 2004; Gómez-Landero, 2010), but are different from the WAG gymnasts (Díaz et al., 2008), who have long upper extremities.

Finally, the RAS values indicated that the arm span was slightly smaller than the height in WP tops, MP tops and WG bases, just like the tops studied by Taboada-Iglesias et al (2015). However, the gymnasts of the RG Andalusian team (Vernetta et al., 2011) and the gymnasts of the Trampolining National Team (Gómez-Landero et al., 2004), have an arm span greater than their height, just like WG and MxP tops, and WP, MxP, and MP bases.

Limitations of the study include not having other samples of men's categories, as it would be interesting to have a sample that includes male groups. However, the authors of this study assume this issue is due to their limited participation in national and international competitions.

CONCLUSIONS

It should be noted that in all competitive categories, both tops and bases have a brachio-brachial morphotype, or short upper extremities, and brachio-skeletal morphotype or short lower extremities, according to the RUEL and RLEL indices. The skeletal index indicated that the WP and MP tops, just like the MxP bases, had long lower extremities, whereas WG and MxP tops and WG, WP and MP bases had medium lower extremities. In terms of shape, all of the groups of tops and bases presented a trunk of an intermediate shape, except for WP tops and MxP and MP bases, whose trunk is of a trapezoid shape. The trunk length is medium in all of the categories, except in MP tops, who have a short trunk, and MP bases, whose trunk is long. Finally, the WG and MxP tops, and the WP, MxP and MP bases have an arm span greater than their height, whereas the WP and MP tops, and the WG bases have an arm span smaller than their height. Hence the importance of paying attention to these differences in body proportionality, in order to guide gymnasts toward a specific competitive category.

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EFFECTS OF PRACTICE STYLE ON A COMPLEX GYMNASTICS SKILL PERFORMANCE OF HIGH-, MEDIUM-, AND LOW-SKILLED LEARNERS

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Original article

Abstract

This study examined the effect of the practice style of teaching in teaching a complex gymnastic skill and compared the achievements of low, medium and high skilled learners on motor skill performance. 46 students of the first highschool grade aged 12-14 years, of two classes, were taught using practice style of teaching the handstand forward roll during (12) lessons, 30 minutes each, 2 times per week. The skill performance has been recorded and evaluated prior, post and two weeks after the end of the program. Based on the initial compound measurement scores, students were grouped into three equal groups of low, medium and high skill. The 3 x 3 analysis of variance (skill level group x test), with repeated measurements in the last factor showed that all the groups have improved their performance both in outcome (quantitative measurement) and in technique (qualitative measurement) of the handstand forward roll and that there were significant effects for the learners' skill level. This study showed that low skilled learners improved to a greater extent, compared to those of medium and high skill, particularly as for the skill outcome.

Keywords: *Practice style of teaching, motor learning, gymnastics skills, adolescents.*

INTRODUCTION

The sports skills are central point of the teaching in most programs of physical education (PE). Key objective for the teacher of PE (TPE), is the implementation of appropriate strategies and methods in order to achieve learning and improvement of motor skills.

The learning of motor skills is a problem related to the control and synchronization of the trunk and the body parts, which must operate in accordance with the time and spatial restraints required to reach the target skill (Magil, 1993). The motor learning occurs as a result of training and experience converting in this way the acquisition of motor experience and practice to the most powerful predictors of skill learning (Silverman, 1996). According to Schmidt, (1991), the practice is the most important factor for the effectiveness of performing a skill, where learning and experience lead to performances with the least effort.

Silverman (2005) states that the more time spent practicing a skill, the more learning will take place. The degree of learning is a function of the relationship between the time actually spent on learning and the actual time it takes (Silverman, 1996). Correlational studies have consistently found out that skill learning is positively related to the number of successful practice trials and negatively

related to unsuccessful practice (e.g., Ashy, Lee, and Landin, 1988).

In physical education classes, the researchers discovered that the time spent on student practice is also related to the effectiveness of teachers (De Knop, 1983), and also to the teaching strategies they apply (Silverman, 1996). The more effective teachers provided their students with the double amount of the engaged skill learning time than the less effective teachers (Phillips & Carlisle, 1983). On the other hand, effective teaching is characterized by a lot of practice time and limited instruction and management (Behets, 1997). Physical education is "learning by doing". The teaching strategies which promote the practice are very important, since students need enough time to learn the motor skills (Silverman, 1996).

There is no single superior teaching style or teaching-learning approach (Mosston and Ashworth, 2002). All teaching styles, when used appropriately, contribute to human development in different ways. Consequently, the use and significance of each individual style will be determined by the teaching objectives. Researchers have recognized that the use of reproductive styles is more suitable for the acquisition of motor skills than productive styles (e.g., Hein, 2012).It is also generally accepted that direct teaching styles are suitable for the improvement of learners' motor performance (e.g., Housner, 1990), and more effective in learning motor skills (Hein & Kivimets, 2000; Siedentop, 1991). Unlike the indirect or child-centred instruction, (Metzler, 1983), the direct instruction relies more on the teacher's initiative, on taking decisions and it is characterized by task-orientation, clear statement of goals, demonstration and explanation of the task, the teacher's control, the close supervision, immediate and task-related feedback (Boyce, 1992; Siedentop, 1991). Teacher-centered (direct) teaching styles can be also considered as controlling behavior whereas student-centered teaching styles as autonomy-supportive behavior.

The practice style is one of the most well-known forms of teaching in PE, from the spectrum of teaching styles of Mosston, (Mosston, 1966), associated with the direct teaching. The practice style largely represents the prevailing form of teaching in schools (Cengiz & Serbes 2014; Salvara & Birone, 2002; Cothran et al., 2005). It has also been found that in professional and amateur sports, coaches use primarily the practice style of teaching during workouts of the year (Hewitt & Edwards 2015).

The practice style of teaching aims at increasing students' practice (Mosston & Ashworth, 2002). On the basis of the theory of spectrum, in practice style the TPE decides on the purpose of the teaching unit, the exact duties or the tasks that must be completed, as well as the criteria of the acceptable performances. The aim of the practice style is to learn the students to work individually, giving time and opportunity to practice in their own pace (Mosston & Ashworth, 2002). The same authors state that, providing a relative independence and freedom gives students the opportunity to maximize practice time. Researchers claimed that the opportunity to maximize the available practice time by students is connected with improving performances (Goldberger & Gerney, 1986; Goldberger, Gerney, & Charnberlain, 1982). Other researchers argued that during the practice style of teaching students receive individual feedback on skills at a higher rate (Byra, Sanchez, & Wallhead, 2014).

According to the research of teaching styles, a relatively small number of studies examined the effects of practice style, in comparison with other styles (command, reciprocal and inclusion), on various motor skill performances (Beckett, 1991; Boyce, 1992; Goldberger & Gerney, 1986; 1991; Goldberger et al., 1982; Griffey, 1983; Harrison, Fellingham, Buck, and Pellett, 1995; Zeng, Leung, Liu, & Bian, 2009). These surveys have highlighted the effectiveness of practice style to improve motor skills, for the majority of learners. However, some contradictions have turned up about the influence of the practice style

in the students' skill level. Other studies showed that the practice style was more effective in medium skilled learners (Boyce, 1992; Goldberger & Gerney, 1986; Goldberger et al., 1982; Jenkins & Byra, 1997), others that was equally appropriate to medium and high skilled learners (Beckett, 1991; Griffey, 1983), but also to students of low potential (Harrison et al., 1995). The researchers attributed these conclusions to the different ages of samples, the nature of learning skills, but also to the different learning environments.

In the specific area of gymnastics, numerous studies have been published that investigated various aspects of learning and teaching of gymnastic skills. Most recent studies highlight the importance of practice in gymnastics as a wide range of new skills must be acquired and the acquisition as well as the retention of complex motor skills presupposes possession of the simpler skills (Delaš Kalinski, Miletic & Bozanic, 2011), of the quantity and quality of practice (Pehkonen, 2010), and of a good organizational strategy in mini-circuits (Ariza, Domínguez, López, & Vernetta, 2011; Vernetta, Delgado, & Lopez, 1996). Also, authors stated that the fundamental movement skills (Culjak, Delas Kalinski, Kezic, Miletic, 2014), the individual positive and encouraging feedback (Delaš Kalinski et al., 2011), and the observation of model with verbal teaching (Maleki, Shafie Nia, Zarghami, & Neisi, 2010), are factors of particular importance for the qualitative acquisition of basic and complex gymnastics skills. Other authors demonstrated that, as a learner acquires a motor skill in gymnastics, this changes the way the learner perceives that skill (Heinen, Mandry, Vinken, Nicolaus, Nunomura, Oliveira, 2013). In addition, there have been several studies that examined differential practice effects within novice and experts gymnasts and highlighted the differences in coordination pattern of expert gymnasts when performing the same skill (e.g., Huchez, Haering, Holvoet, Barbier, Begon, 2016). However, there were only a few surveys on issues related to the impact of teaching styles, in particular for the practice style, on the learning of gymnastics skills in schools. The most recent research refers to the reciprocal teaching and "task assignment", using a mini-circuit organization, and it relates to University students (Santana, Sánchez, & Bedoya, 2015).

From the literature review (Chatoupis, 2009; Goldberger, Ashworth, & Byra, 2012), it seemed that the impact of the practice style on different motor skills as well as on the skill level of the students have not been adequately studied by researchers. The lack of relevant studies in the field of gymnastics and the implementation of longer duration programs, make this study necessary and of special interest. The gymnastics skills integrated into curricula of PE, are mostly complex sport skills and present special difficulties, especially for low-skilled students. Complex skills include control and synchronization of a larger number of body parts, and demand more practice to be acquired (Schmidt, 1991). It is accepted that, higher skilled learners typically have higher amounts of successful practice than the lower skilled peers (Herbert, & Landin, 1996). However, it is very likely the students of different skill levels to exploit differently the potential provided by the practice style, to increase their individual practice, and there might be different impact on their learning.

The findings related to the motor skill learning have their own significance in the field of PE. It is also important whether there are differences among learners of different skill levels when taught with practice style of teaching. The purpose of this study was to examine the influence of practice style of teaching in outcome and technique performance of a complex gymnastics skill, like the handstand forward roll, on highschool first grade students; in addition, to compare the effects of practice style on low, medium and high skilled students' motor performance. In this study, the practice style was chosen for the research because this style of teaching was

used more than any other style (over 50%), out of the total of TPE in schools (Cothran et al., 2005).

METHODS

The participants in the study were 46 students aged 12-14 years (*M* = 12.7, *SD* =. 44), of two classes of the first highschool grade in a semi-urban school. After the selection of the school that served the needs for the realization of the present study, a relevant authorization was requested from the competent departments of the Department of Primary Education and the Director of the school. Also, the guardians' written consent for the pupils' participation was requested because the subjects in the sample were minors. All attendees participated voluntarily, took part in all the tests and had full participation in courses while they had no athletic experience in gymnastics.

Treatment. On the basis of the PE curriculum of the grades of the school four (4) small homogeneous groups (2 of boys n = 27, and 2 of girls n = 19) were formed in order to facilitate teaching. All groups followed the same teching style (practice), and the same training program to learn the handstand forward roll. They also, had equal practice time and used the same tasks and the same equipment. Furthermore, there were specific positions and equipment, for each task and students practiced two by two in each equipment. In each lesson, students practiced circular in four tasks, both of which focused on learning the handstand forward roll and the rest on different gymnastics tasks. Totally six (6) tasks were used for learning the handstand forward roll, referred to in the relevant literature (Knirsch, 1998). The methodological progression was consisted of six distinct tasks: (1) performing forward rolls down hill, (2) swing to handstand on a mat against a wall with support, (3) candlestick (3-5 sec) and rolling forward to stand up,(4) front support from a stack (height: 0.70 m), kicking up using one leg to handstand, and rolling forward onto a gymnastics mat, (5) front support with feet elevated up wall to handstand and rolling forward onto a gymnastics mat, and (6) performing the swing to handstand and rolling forward to stand up onto a gymnastics mat. A progressive partial teaching strategy was used which included the individual practice of each part of skill and then composition. The first two tasks were used in 1st-4th, the next two in the 5th-8th and the last two in the 9th-12th lessons.

The teaching was by the same TPE, who had sufficient experience in the application of the practice style of teaching of Mosston & Ashworth, (2002). Moreover, to ensure the validity of the experimental process and teaching style, detailed course plans were followed and all the sessions were tested by the researcher.At first, there were two (2) preliminary lessons for the students to understand the teaching style and the whole process. Then the main program was carried out, which was completed during (12) lessons, 30 minutes each, 2 times per week. At the beginning of each lesson, after a five-minute warm-up, the TPE explained and demonstrated the tasks that should be learnt, recalled the roles of students and teacher’s role towards the students. Then the opportunity was given to students to practice, having at their disposal the instruction sheets and the criteria for each task. Each sheet included illustrations and instructions on how to perform the task, highlighting five (5) key points of the technique that the students should remember. During the exercise, the TPE provided individual and private feedback, on the movement quality and systematically moved students to the next station, every five (5) minutes. Manual assistance was provided when necessary. After each station change, as well as at the end of the lesson, the teacher provided also summary feedback and highlighted the key points of the tasks.

Skill. A gymnastics skill was chosen that was unknown to the students of the 1st high school grade, but which is included in the PE curriculum. That skill was the handstand forward roll, a complex skill. It consisted of connecting two individual

elements, the handstand and the forward roll. It is an easy task for gymnastics athletes but relatively difficult for beginners high school students, as it requires, among other things, the development of the necessary nerve-muscle coordination and various abilities, such as strength support, balance, orientation etc. and therefore requires enough training to be assimilated.

Skill test. Prior to the instructional phase of the study all subjects were pretested on their ability to perform the handstand forward roll. Pretesting was conducted to determine the learner's level of skill prior to receiving instruction. Following the treatment phase of the study all of the subjects were posttested to determine the effects of the treatment on learner skill performance. The retention of learning was tested after two weeks followed the same protocol used during the pretest and initial posttest.

The evaluation process included a quantitative measurement (*outcome*) and a quality measurement (*technique*). The execution in handstand forward roll evaluated through video and using a subjective assessment scale established in cooperation with two experienced gymnastics trainers. Trainers subdivided the task in ten separate phases of movement (see figure 1), identifying the main movement features of each part, and then determined the proper implementation criteria with corresponding reductions of each part of the task omitted or was executed with mistakes. Each one of these ten parts of the task was marked with one (1) point, giving a score range from 0 up to 10 points. Technique mistakes have been subdivided into three main categories, small, medium and big mistakes, with corresponding reductions of 0.10, 0.20 and 0.40 points, based on the code of points (F.I.G., 2009). The size of the deviation from the correct execution of each part of the movement defined the mistake category. Such errors related to incorrect positions of the body parts, the bad range and dynamic of the movement, the lack of pace, as well as small, medium or large assistance by the TPE, during the task execution. Similar methods of evaluating the execution of the tasks in physical education are also described by other authors (Majerič, Strel, & Kovač, 2016).

"*Outcome*" assessment included the measurement of points from the task parts the student performed. The parts of the task omitted or executed with very poor technique were not assessed. The score of each student in outcome was the total number of the task parts the student could perform. Therefor, outcome scores are total number of separate phases of movement executed in the best trial

"*Technique*" assessment included the measurement of reductions for the technique mistakes appeared in each part of the task. Then the score of reductions were deductible from the outcome score and the final result was the student's technique score of the task. Therefor, technique scores are the number of separate phases of movement demonstrated without mistakes in the best trial.

Coding Procedures. To assess coding biases and reliability, three trained coders who were trained by one of the trainers coded each subject's tests (pre-post- and retention) twice. At first, they learned to evaluate properly the execution of the handstand forward roll, observing 10 different students. Then, after having coded 10 different students, the coders' scores were compared to those of the trainer. If agreement was less than 90 percent, then the training program was repeated and up to achieve the reliability criterion of 90%. The coders coded independently the videotaped skill performances and didn't know the group in which the students have joined in order to ensure the validity. Scores were, in each case, the average of the scores of the three coders.

Percentage agreement and intra-observer reliability was calculated using intraclass correlation coefficient (ICC; Fleiss & Cohen, 1973). The ICC values were given with 95% confidence intervals. An ICC value greater than 0.75 was considered as excellent agreement, 0.40 to

0.75 was fair to good and below 0.40 was poor. In the present study the intra-observer reliability both for outcome and technique were excellent (outcome: pretest .94 to .96, posttest .96 to 98, and technique: pretest .95 to 98, posttest .94 to .96). Similarly, the inter-observer reliability for outcome (.95 to .98), and technique (.94 to .96), were excellent.

Skill Level Procedures. In order to examine the influence of ability level on learner's skill performance in handstand forward roll all students were classified into three equal groups (low-, medium- and high-skilled). The above groups, low-skilled (LS; n = 16), medium-skilled (MS; n = 15), and high-skilled (HS; n = 15), arose after calculating and arranging hierarchically students' pretest complex scores (outcome and technique) and were divided by three. In Table 1 the pretest means for skill performance scores in handstand forward roll by ability group are presented. Regarding the learners' sex in each group's structure, the girls held the 31.25% of the low-skilled group, 40% of medium-skilled and 53.3% of high-skilled, compared to the other percentages of the boys. We realize that this confounds skill level and gender. But given the irregularity of the sample and that gender-based programming in PE classes, is considered unnecessary and since mandates separate instruction only by skill level, the results for skill level will be presented here.

Data analysis. Separate two-factor 3x3 analysis of variance (skill level group x test), with repeated measurements on the last factor (MANOVA) were used to examine student learning (from pretest to posttest and to retention test) for each skills test and to detect if one group was superior to each other. In total, two analyses of variance were conducted for each independent variable (outcome and technique) on handstand forward roll. Bonferroni *post hoc* analysis was also conducted to detect statistically significant differences between the levels of each factor and analyses of simple main effects were conducted to examine the interactions between the factors.

RESULTS

Descriptive statistics. Descriptive statistics for each test and group for skill performance (outcome and technique) on handstand forward roll are presented in Table 2. All groups improved their performance from pretest to posttest and to retention test, both in skill outcome and in skill technique. The LS group showed the greatest improvement over the rest with a change score (gain) from the pretest of 2.12-2.22 points for the skill outcome, and of 1.42-1.46 p. for the skill technique. In contrast, the lowest progress was shown by the HS group, with a corresponding change score of 1.33-1.36 p. and 1.02-1.06 p., while showing the highest average scores in all tests, both in skill outcome and in skill technique.

Skill Outcome Performance. The 3x3 analysis of variance (skill level group x test), with repeated measurements (MANOVA), showed significant differences in the "test" factor ($F_{2,86}$=119.14, p<.001). A Bonferroni *post hoc* analysis revealed that all students showed significant progress from pretest to posttest and to retention test, with no changes from posttest to retention test. The effect of the "test" factor was tested separately at each level of the "skill level group" factor, and showed significant differences for the LS group ($F_{2,30}$=29.62, p<.001), the MS group ($F_{2,28}$=91.28, p<.001), and the HS group ($F_{2,28}$=90.08, p<.001). Tests of between-subjects effects showed that there was a significant primary effect of the "skill level group" ($F_{2,43}$=19.30, p<.001). A Bonferroni *post hoc* analysis revealed significant superiority of HS students, compared to those of LS and MS (p <.001).

Tests of within-subjects effects also showed that there was a statistically significant interaction between the factors "skill level group" and "test" ($F_{4,86}$=2.56, p<.05). A Bonferroni *post hoc* analysis showed a significant improvement from

pretest to posttest and to retention test for the LS group, and no significant improvement for MS and HS groups. For further control of the interaction the analysis of simple main effects was used which showed significant differences between the three groups for pretest ($F_{2,43}$=49.64, p<.001), posttest ($F_{2,43}$=10.12, p<.001), , and retention test ($F_{2,43}$=9.75, p<.001). A Bonferroni *post hoc* analysis showed that in the pretest the HS group was superior to MS, which was also superior to LS. In the posttest and retention test there were no significant differences between the LS and MS groups, whereas HS significantly exceeded the above groups. Figure 1 shows a trend to reduce the difference between the three groups from the posttest and the retention test for the outcome performance on handstand forward roll.

Skill Technique Performance. The 3x3 analysis of variance (skill level group x test), with repeated measurements (MANOVA), showed significant differences in the "test" factor ($F_{2,86}$=105.74, p<.001). A Bonferroni *post hoc* analysis revealed that all students showed significant progress from pretest to posttest and to retention test, with no changes from posttest to retention test. The effect of the "test" factor was tested separately at each level of the "skill level group" factor, and showed significant differences for the LS group ($F_{2,30}$=22.10, p<.001), the MS group ($F_{2,28}$=149.44, p<.001), and the HS group ($F_{2,28}$=83.21, p<.001). The pretest scores of all three groups were significantly lower than those of posttest and retention test, and there were no differences between the posttest and the retention test. Tests of between-subjects effects showed that there was a significant primary effect of the "skill level group" ($F_{2,43}$=14.50, p<.001). A Bonferroni *post hoc* analysis revealed significant superiority of HS students, compared to those of LS and MS (p <.001). Moreover, LS and MS students did not differ significantly. Table 2 shows that the HS group had the highest means in the pretest (M=3.05), in the posttest (M=4.07), and in the retention test (M=4.11).

Tests of within-subjects effects also showed that there was no statistically significant interaction between the factors, "skill level group" and "test", ($F_{4,86}$=1.13, p>.05). For a more detailed investigation, the analysis of simple main effects was used which showed significant differences between the three groups for pretest (F2,43 = 37.85, p <.001), posttest (F2,43 = 8.19, p <.001), and retention test (F2,43 = 8.23, p <.001). A Bonferroni *post hoc* analysis showed that in the pretest the HS group was superior to MS (p<.001), and MS group was superior to LS (p<.05). In the posttest and retention test there were no significant differences between the LS and MS groups (p>.05), whereas HS differ significantly to MS (p<.05), and LS (p<.001) groups. Figure 2 shows a trend to reduce the difference between the three groups from the posttest and the retention test for technique performance on handstand forward roll.

Table 1.
Composite pretest scores for skill performance by Subject Group.

Groups	N	M	SD	Range	Min-Max
LS	16	1.80	.27	.82	1.33-2.15
MS	15	2.55	.21	.58	2.22-2.80
HS	15	4.13	1.14	3.02	3.08-6.10

Table 2.
Descriptive Statistics for each test and group for outcome and technique performance on handstand forward roll.

Groups	N	pretest		posttest		retention test	
		M	SD	M	SD	M	SD
Outcome							
LS	16	2.40	.42	4.52	1.67	4.62	1.71
MS	15	3.34	.26	4.99	.74	4.90	.74
HS	15	5.20	1.30	6.53	1.27	6.56	1.25
Technique							
LS	16	1.19	.17	2.61	1.34	2.65	1.34
MS	15	1.77	.30	2.92	.42	2.88	.49
HS	15	3.05	1.00	4.07	1.14	4.11	1.17

Note. Outcome scores are total number of separate phases of movement executed in the best trial, while technique scores are the number of separate phases of movement demonstrated without mistakes in the best trial.

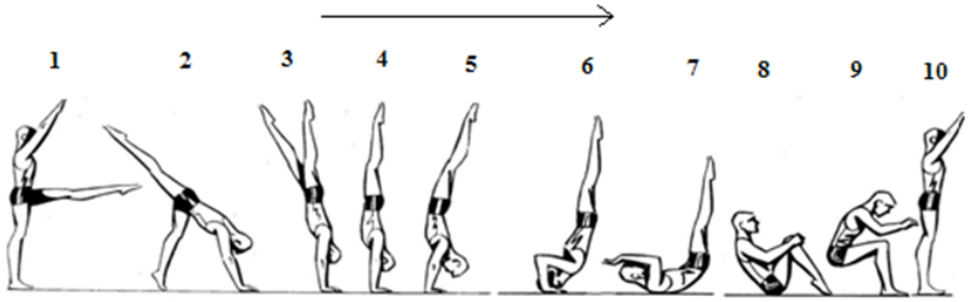

Figure 1. The ten selected phases of handstand forward roll performance.

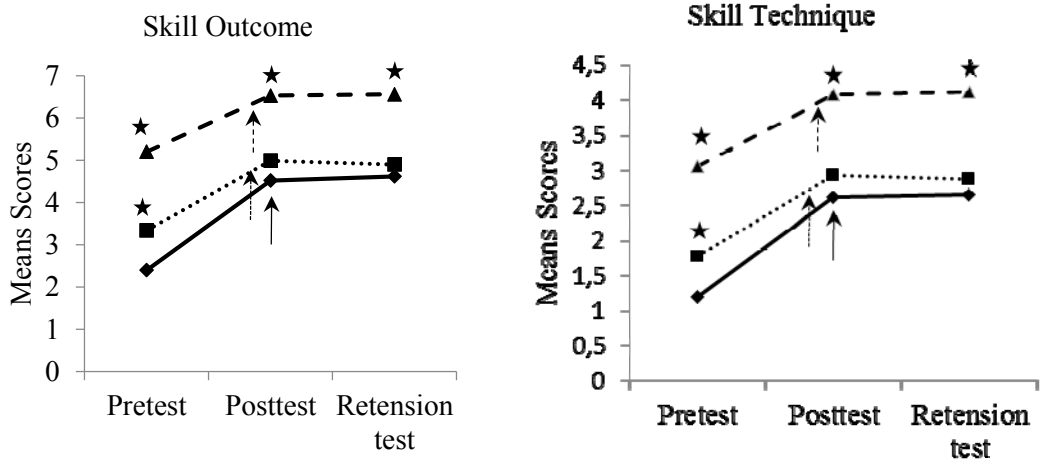

Figure 2. Interaction between skill level group and test for outcome and technique performance on handstand forward roll. Low-skilled (continuous lines), medium-skilled (dotted dots), and high-skilled learner (dotted lines). Statistically significant differences at the 0.05 level between the three groups at each test are denoted by asterisks. Statistically significant differences at the 0.05 level between the three tests for each group are denoted by arrows. *Note: Outcome scores are total number of separate phases of movement executed in the best trial, while technique scores are the number of separate phases of movement demonstrated without mistakes in the best trial.*

DISCUSSION

In the present study the effect of practice style of teaching was examined in the *outcome* and the *technique* performance of the handstand forward roll, in high school first grade students. In addition, the differences among students of different skill level were checked in skill performance. The results of descriptive statistics revealed that all students showed a significant increase in average terms, from the pretest to the posttest and the retention test, showing more parts of the skill (*outcome*), and achieving better quality of movement (*technique*). These results suggest that learning took place during the teaching period and that teaching in the context of practice style had a positive effect, regardless of the students' skill level. These findings come in agreement with the results of other researchers (Babatunde, 2014; Beckett, 1991; Boyce, 1992; Goldberger & Gerney, 1986; Goldberger et al., 1982; Santana, Sánchez, & Bedoya, 2015).

The analysis of the multiple comparisons test showed that there were no changes among the scores of the posttest and the retention test (*outcome* and *technique*), for all groups. These findings confirm that learning was preserved significantly, during the two weeks retention period, regardless of the students' skill level. The above findings are reinforced by the findings of other surveys (Beckett, 1991; Boyce, 1992; Goldberger & Gerney, 1986), and are of particular interest, because, in the research of teaching style, the retention period was omitted. As is generally accepted the retention tests are very important in the evaluation of the effectiveness of the teaching method in learning providing information regarding motor skills that had been acquired or not and should be done after a short period of time (i.e. 1-2 wks), without any practice or feedback and under the same practice conditions (Magill, 2007; Schmidt & Lee, 2011). In the present study, it was decided to examine the retention of learning after a 2-week interval, which, according to the above authors, was proportional to the period of the practice phase (12 wks). The fact that there has been significant retention in the improvement of the motor task goal after two weeks can be speculated that it is related to the possibility of maximizing the available practice time, since students in the practice style of teaching are practiced individually and privatelly, at their own pace. Also, based on the multidimensional nature of learning in PE, the above were strongly depentent on the type of motor skill (closed complex gymnastics skill), on the methodological approach (progressive partial strategy) and on the way of organizing practice (circular practice at stations) followed in this study. These findings could be verified by the findings of earlier studies that have shown that a "mini-circuit" organization provides a more comprehensive approach to gymnastics training methodology, which produces significant learning retention, and from a pedagogic perspective, is the best strategy for children (Ariza et al., 2011; Vernetta et al., 1996). The authors have highlighted the need to address the learning of these types of skills through specific practical strategies that enhance the relative relationship of the various components of skills (varied through global or individual exercises), also confirming the close relationship between increasing student practice and organizational strategy in mini-circuits, and providing frequent and qualitative feedback from the teacher.

Regarding the influence of the practice style of teaching to the learners' skill level, this study results showed that high-skilled learners excelled significantly the rest, medium- and low-skilled, which did not differ either in *outcome* or in *technique* performance of the handstand forward roll. However, LS learners showed the greatest progress, especially in relation to MS learners, covering important differences in skill *outcome*, while HS learners showed less improvement. The same image was also observed for skill *technique*, although there was no statistically significant interaction.

The above findings confirmed the assumption of research on differences in learning, in relation to the students skill level, and showed that the practice style of teaching has benefited more the low-skilled learners less the medium-skilled and even less the high-skilled learners. These findings contradict those researchers who argued that the practice style was most effective in medium-skilled learners (Boyce, 1992; Goldberger & Gerney, 1986; Goldberger et al., 1982; Jenkins & Byra, 1997), as well as those that showed it was equally appropriate to medium- and high-skilled learners (Beckett, 1991; Griffey , 1983). This study support the findings of Goldberger and Gerney, (1991). In their study, it was found that low-skilled fifth grade students in primary school, who have implemented two alternative forms of practice style of teaching, have improved most of the others, medium- and high-skilled, in a football punting skill performance. These findings also supports in part the research of Harrison et al., (1995) who found that the practice style helped more the low skilled college students in performance on spike in volleyball, while it did not work equally in the other skills (serve, set and forearm pass), where medium- and high-skilled students were better. These findings raise the question why low ability learners have increased their performance more than those of medium and high ability, since they started learning the handstand forward roll from a lower base. Also, on the other hand, it can be assumed that, learning this complex skill would facilitate in a greater degree the higher ability learners, as they present a better control and coordination of the body parts. These unexpected findings was difficult to justify and guesses are even made.

It is obvious that, althought all students followed the same teaching style and they had the same amount of time to practice in the same tasks, using the same methodological approach, the style and structure of the teaching were not proportionally effective to the students in each skill level.Perhaps the freedom and independence provided through the practice style of teaching has been more beneficial for low-skilled students to show more practice, since they did not expect to be in the series to practice the tasks. In addition, it is likely that the methodological process followed (progressive and gradual composition of skill) was more appropriate for lower-skilled students to be encouraged to practice separate segments of this complex skill. As Silverman reports (2005), practice difficulty can affect attitudes and practice. More easy goal tasks can help low-skilled students to have more appropriate practice trials. On the other hand, they may have worked negatively for higher-level students and have become inactive or disregarded for tasks. Possibly, implementing a holistic strategy would help them more, due to their acquired ability to improve performance. The complexity of the skill is treated differently by an experienced trainee and this allows for significant reduction in the number of segments in which the learning ability can be separated (Schmidt, 1991).

Trying to explain all the above findings, we can also speculate that: a) the low ability students showed the greater degree of progress because, in relation to the others they had much more room for improvement, as they were in a completely original stage of the skill learning, where learning is faster, b) high ability students showed the least increase possibly because they were at a more advanced stage of learning the skill that functioned as a ceiling effect, c) medium ability students had an average improvement, as they were on a modest stage of learning the skill, d) the predetermined practice time was not appropriate for every skill level, i.e., high ability students might need more practice time to show improvement in skill performance compared to low ability students, and e) the feedback given by the TPE benefited more the low ability students, a result that was found in similar studies (Ernst, & Byra, 1998; Rikard, 1991).

Regarding the significant improvement in skill *outcome* but not in skill *technique*,

this was possibly explained by the difficulty and complexity of the task. Perhaps this athletic skill required more teaching time for a more substantial improvement that is justified by the low scoring change in students' performance. This finding suggests also that beginners achieved easier and in a greater degree the coarse features of the skill, while they control less the subtle changes that need to be done to improve the quality of the movement.

CONCLUSIONS

In conclusion, the findings of this study provides evidence to verify that the practice style of teaching might be an appropriate choice for learning complex gymnastics skills, which require enough practice. The results, also, indicates that the practice style of teaching helps high school students to improve in both *outcome* and in *technique* of handstand forward roll, while it seems more effective for low-skilled students, particularly on skill outcome performance. However, the relatively small number of participants limits the generalization of results for every type of athletic skill. Further research will be needed in larger and differentiated samples in more and different type of skills, as well as in several areas of development (cognitive, emotional, social, moral).

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ROLE OF THE MENTAL REPRESENTATION IN ENHANCING MOTOR LEARNING AND PERFORMING GYMNASTIC ELEMENT

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Original article

Abstract

The aim of the present study was to analyze the effect of three intervention modalities ((a) external visual imagery modality, (b) verbal feedback modality and (c) visualization modality) on the Roll backward to handstand. 42 females' students (age 20.6 ± 1.3 years) voluntarily took part in this study. Subjects were assigned into three groups according to three learning modalities: mental imagery modality, verbal feedback modality and visualization modality. During the two testing sessions (before and after training sessions), the participant was marked according to the FIG Code of Points. The results thus reveal a significant effect on the training, therefore on the learning of the backward roll followed by a handstand by the method of mental imagery. Thus, the mental imagery seems to be a tool for transmission of knowing and training by excellence making it possible to the students to progress while getting rid of the lack of motivation, organization, implication and work. Moreover, the results gathered following the gymnastic practice also show an improvement of the performance of the first group that had to undergo training by verbal feedback. This supports the idea that the training by the method of verbal feedback improves the technical performance of a gymnastic element. However, the method of training by visualization of a model appears to be the less developed by the participants in comparison with the mental imagery and the verbal Feedback.

Keywords: *sensory feed back, motor learning, female, acrobatic.*

INTRODUCTION

A handstand, as a key exercise of the contemporary gymnastics, was a static acrobatic exercise where the body was maintained in the equilibrium position with the hands pressed into the floor (Tipton, 2011). Handstand exercise was performed in many sports activities for both men and women such as: sports aerobics, fitness, sports acrobatics, and sports gymnastics. Moreover, it was an integral part of various key positions in break dancing (freeze and kick); it was a starting position in high diving, a position in synchronized swimming (with a head submerged in water and the legs stretched out of it), an integral part of martial arts such as caper or Eastern skills such as yoga. The specificity and the

significantimportance of a handstand were found particularly in sports gymnastics. In fact, many gymnastics' experts have still been discussing and writing about the handstand exercise because it was a basic acrobatic skill which appears in various forms and with different purposes on all the apparatus of the gymnastics all-around (Arkaev & Suchilin, 2009). Accordingly, the quality and success of a performer depended mainly on his technical performance. Similarly, his poor performance was certainly going to have a significant impact on all other exercises whose technique was associated with it. The variations of handstand form play as well an important role as an initial and final position of some of the gymnastics elements mainly in artistic gymnastics. However, back swing connections during gymnastics acrobatic series considerably influence technical performance and difficulties and would allow best performance and lower the risk of falls. In artistic gymnastics, the fundamental movements are decisive to successfully and safely perform acrobatic elements. In this respect, the choice of the technical preparatory Roll backward to handstand elements provide a base for more advanced motor skills and is crucial for optimal performance (Gallahue & Ozmun, 2005). So, this fundamental movement was chosen according to the following criteria: (1) it is teaching topics in Exercise Science and physical education curriculum; (2) according to the participant's abilities and pre-knowledge students can learn the same and similar artistic gymnastics skills (Delaš Kalinski, 2009); (3) these skills represent basic skills in artistic gymnastics. Examining and developing the mental aspects of the handstand could help gymnasts develop more self-confidence and consistency (Calmels et al., 2017) It was also assumed that the mental representations were in fact hierarchically organized memory structures comprised of cognitive units specified as Basic Action Concepts (Schack & Mechsner, 2006) and that the arrangement and clustering of these BACs (Basic Action Concepts) controls and guides skill execution. Despite the fact that handstand is one of the most important basic exercises of the sports gymnastics, (Bolković & Kristan, 2002; Čuk et al., 2009; Živčić Marković K., et al., 2015; Novak et al., 2008;) only little attention was paid to mental practice as far as the training condition of this exercise was concerned. These mental skills were more particularly the practice of the mental imagery and the training by visualization of a model (Schmidt, 1993; Chalghaf et al., 2013). Accordingly, "Imagery, in the context of sport, may be considered as the creation and re-creation of an experience generated from memorial information, involving quasi-sensorial, quasi-perceptual, and quasi-affective characteristics, that was under the volitional control of the imager, and which may occur in the absence of the real stimulus antecedents normally associated with the actual experience" (Morris et al., 2005, p19). Part of this process is the detection of errors, which was the result of an actual-target-comparison, the comparison between real and expected performances of the learner because the concept of how the expected performance of the learner should be like, may be clearer. However, little was known to date on imagery use in gymnastics, with only few studies focusing on imagery use in this particular sport. Given the versatility and importance of imagery in general sports (Morris et al., 2005) and in gymnastics in particular (Fournier et al., 2005), this study focuses on imagery practice and on Roll backward to handstand, as a different form of handstand that was the result of a multitude of motor actions that require balance, stability and sheathing the body for later transfer of learning other technical elements. Thus, the aim of the present study was to analyze the effect of three different intervention modalities

(a) external visual imagery modality, (b) verbal feedback modality and (c) visualization modality on Roll backward to handstand in order to determine the most appropriate way for enhancing motor learning on gymnastics' actual execution. Concerning the hypothesis, it was expected that the external visual imagery is the most effective method in improving the technical performance of a gymnastic learning situation.

METHODS

Participants were 42 female students (age 20.6 ± 1.3 years) voluntarily took part in this study. They were sport science's students pursuing degrees in Exercise Science and Physical Education at the University of Manouba, ISSEP Ksar Said Tunis (Tunisia) and they don't have some previous experience in performing this skill. All the subjects have undertaken the same training program with the same gymnastics teacher and under the same work conditions (the same day during the morning in a well-equipped gymnasium) and with no previous experience of Roll backward to handstand. The subjects were randomly assigned in three equal groups to different conditions. The choice of the population of the present research seems paramount to the installation of the studies so that the relations between these variables can be analyzed. None of the participants had received formal cognitive imagery treatments whether specific or general before. It was made clear to them that participation was entirely voluntary and anonymous and that their answers would remain strictly confidential and the data will only be of use to scientific research.

The present study was conducted in three phases. During the first phase: participants completed Vividness of Visual Imagery Questionnaire in the purpose of determining those with clearness and richness of the mental images generated. Then they will be incorporated into the imagery condition during the experimental sessions. As a result, three experimental groups have been formed and were engaged in the following three experiments modalities as follow: (a) external visual imagery modality (group good visualizes), (b) verbal feedback modality and (c) visualization modality (groups poor visualizes). Pre-intervention base line measure of Roll backward to handstand (pre-test) of participants was carried out during this phase aimed at provided evidence that the improvements of sprint performance after experimental conditions were caused by the condition themselves. During the two testing sessions (before and after training sessions), the participant was marked according to a point code (FIG, 2003).

During the second phase: researchers used the same class level and taught six training gymnastics lessons according to the three learning modalities. Before the experiment, none of subjects had ever specifically performed mental preparation with the aim of improving motor performance.

During the third phase: participants performed Post-intervention measure of Roll backward to handstand (post-test) under the same experimental conditions as the pre-test. Participants were debriefed about the goal of the study once all experimental sessions were finished. Moreover, subjects received their own performance results of each test performed during the study. Experimental protocol was performed in accordance with the Declaration of Helsinki for human experimentation and was approved by the ethical committee. Out of respect for the research ethics, informed consent forms were read and signed by the participants. This study took place in February of the 2015-2016 academic years.

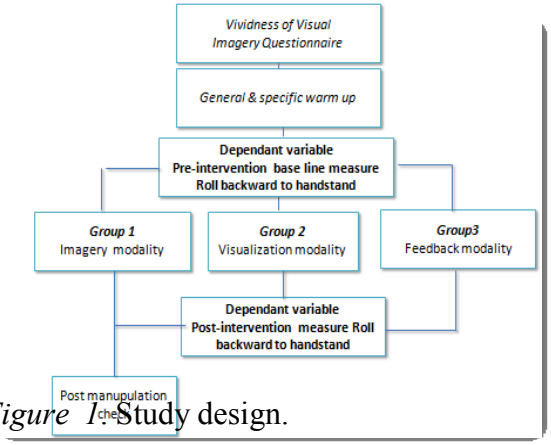

Figure 1. Study design.

Measures

- Gymnastics performance

During test and post-test participants executed Roll backward to handstand and their performance was recorded by a digital video camera. Video analysis was established with a Sony video camera (DCR PC 105E, 50 Hz) in order to analyze final value of the deduction. Recorded performances of the participants were watched and evaluated once again by three Judges mainly for the final value and technical of the deduction. Qualitative data for each participant were collected by using a scorecard for execution faults (FIG, 2003). All tests were applied at the same day and by the same evaluators. There were University professors and national judges (N=3) with more than 20 years of experience of work in various Tunis sports clubs and Faculty of Physical Education and Sport. The evaluation of each participant was based on regulation in Code of Points to mastery in technical skills (Brüggemann, 1994). The judges rated the participants' performance independently and through video analysis. The judges did not know which participant was assigned to which experimental condition. Any deviation from the correct position is considered as mistakes and the judges made deduction according to the FIG Code of Points (2013-2016).

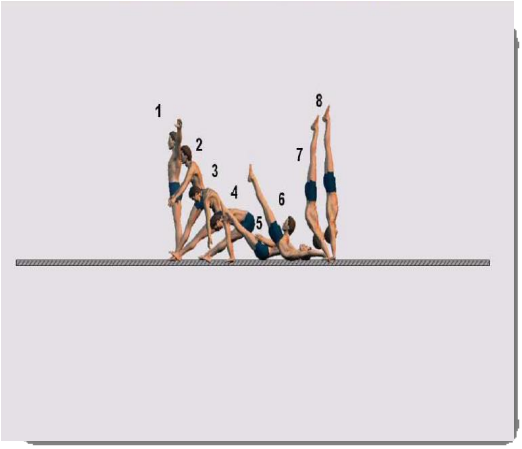

Figure 2. Stages of roll backward to handstand performance (FIG 2003).

- Evaluation Process

A scorecard was established for assessing Roll backward to handstand technique before and after /the training sessions. The five technical criteria studied were chosen according to the Table of General Faults and Penalties the FIG Code of Points (2013-2016). The level of the performance was videotaped (at the beginning and at the end of the program) and evaluated according to standard procedure on a five-point Lakers scale. Evaluation was based on the FIG Code of Points (2013-2016), but adjusted in order to be suitable for the PE curriculum, as follow:

Table 1

Evaluation criteria for judging student' performance during Roll backward to handstand (Execution faults and penalties).

	Deviation from straight direction	Body Posture fault	Reach handstand prior to landing	Perfect standing position	Dynamism/coordination for each variable based
Very good 1pts					
Good 0.8 pts					
Medium 0.5 pts					
Weak 0 pts					

Score /5

Process of evaluating Roll backward to handstand element was simple and according to code of point' regulation **(**COP). Performance was evaluated following the expectations of perfect performance. All deviations from this expectation are deducted.

Table 2
Deviation faults and penalties.

Fault	Deduction (pts)	Description
Perfect	No deduction	No deviation
Small	0.10	Deviation less 15o
Medium	0.30	Deviation less 30o
Large	0.50	Deviation less 45o
Very large	1.00	Fall at landing/no recognition

Total error score was calculated and deductions for errors in execution are added together and then deducted from 5.00 points to determine the Execution- Score (FIG Code of Points 2013 – 2016). A 5-Liker point was used in all three intervention methods. Very strong performances received a 5 point score as maximum cumulative score for best execution whereas unsuccessful performances received a 0 point score when participant did not perform element or else in the case of no recognition of movement.

- The mental imagery condition

Participants rehearsed Roll backward to handstand mentally in an external perspective during the gymnastics lessons and after each actual execution. During actual condition, participants were put in real-life situation and asked to perform exercise as they would at a situation test during 30 seconds (s) (Calmels & Fournier, 2001).

Thus, instructions were precise on the technical realization of gymnastic element. To generate, then to control mental work, a script of imagery was given to participants which was based on a previous research (Hammoudi-Nassib et al., 2014;Hammoudi -Nassib et al., 2017): "You have 30 s during which I would like that you visualize yourselves carrying out Roll backward to handstand as perfect as possible. Please, close your eyes and imagine that you established a new perfect performance". At my signal concentrate, then when you are ready, start to imagine the sequence without moving.

Interview post experimentation

To check if the students have realized experimental conditions in accordance with instructions given, they were questioned about their imagery perspective and nature and vivacity of image associated (Gould, 1980; Cumming, 2007).

- Visualization of a model

During the second modality, participants were seated at a table in the room adjacent to the gymnasium and were viewing exercise twice during 30 s, one at real time and one in a slow motion than in actual execution. Teachers had frequently recourse to immediate videotaped actual execution. So, video sequences of Roll backward to handstand which they should perform were presented to participants during gymnastics lessons and after each actual execution. Participants visualized performance achieved previously with a comment with reference to expectations of a perfect performance and deviations from this expectation.

- Retroactive verbal feedback

Effective instruction may be crucial to the pursuit of optimal sporting performance (Hodges & Franks, 2002; Schmidt et al., 2004). So, in the present study, the role of the physical education teacher is to give information about Roll backward to handstand' execution in the form of verbal and visual feedback as a key tool in improving and learning motor skills. Accordingly, teacher provides instructors' feedback in positive form about errors, corrections and encouragements with presentation of shapes and sketches to facilitate performance of task and to enhances attention and provides additional information that may not be available through visual observation (i.e., impulse to handstand, body position during the

movement…).

- Vividness of Visual Imagery Questionnaire (VVIQ)

Before Imagery condition, the VVIQ (Marks, 1973) translated and adapted in French by Denis, 1979 was used to monitor the participants' statements describing various scenes, which they must visualize mentally. Participants' vividness of the image was evaluated in order to determine the richness of the mental images generated to be able to incorporate thereafter. The vividness of the image is rated along a 5-point scale. The questionnaire has been widely used as a measure of individual differences in vividness of visual imagery. The large body of evidence confirms that the VVIQ is a valid and reliable psychometric measure of visual image vividness. VVIQ assesses vividness of visual imagery using 16 items in four groups of 4 items in which the participant is invited to consider the image formed in thinking about specific scenes and situations. So that higher scores reflect higher vividness. Participants form a series of images of a friend or relatives face, the rising sun, a shop, and a country scene. Ratings of image vividness were made on a five-point scale, ranging from 1, perfectly clear and vivid as normal vision, to 5, No image at all, you only "know" you are thinking of the object. Participants answered questionnaires in groups, with the presence of a tutor who acted as the experimenter. They were asked to seat themselves as far apart as possible in the room. Responses were made in silence, and participants were told not to put their names anywhere in the booklet.

Participants answered questionnaires in the order in which they appeared in the booklet. An individual score from 0 to 64 was calculated, which made it possible to classify participants in "good visualizes" and "poor visualizes". In the version of Marks, 1973, there were two levels of scores derived in a population of students; "good visualizes" (average = 3.25) and "poor visualizes" (average = 1.64), i.e. participants in good capacity of visualization (vividness) and participants in low capacity.

Qualitative and quantitative data were collected within average from observation grids composed by criteria of success of the technical element and which were translated in the form of marks based on the codes of marking. Inter-rater reliability of Roll backward to handstand' scores were analyzed using intra-class correlation coefficient (ICC), with a value of 0.7–0.8 being questionable and 0.9 indicating high reliability (Vincent, 2005), and standard error of measurements (SEM) calculated by dividing the standard deviation of the difference between scores by √2 (Hopkins 2000). All the values are expressed in the form of average ± standard deviation. For the quantitatively data analysis, the score allotted to each participant was compared before and after training for each method, to do so, the analysis of multiple variance ANOVA was used. Effect size was calculated for all ANOVAs with the use of a partial eta squared (η^2) <0.01 = small, 0.01-0.06 = medium, and > 0.06 = large).

This statistical analysis was used to study correlation between various variables of our study namely: effect of training for each method of training on performance, comparison of inters group performance and groups/training interaction. Percentage of delta was also calculated: Δ%= (T1-T0) /T0×100; T0 is equal to the average initial performance of T1 and the average of the representation. Software Statistics version 3 was used for all of the statistical analyses. The threshold of significance was fixed at $p<0.05$.

RESULTS

The interclass coefficient of correlation (ICCs) ranged between 0.94 and 0.98 indicating very high inter-rater reliability. ICCs were also very high in each of the

session (Table 3).

Table 3
Inter-rater reliability of the scores.

Session	ICC3.1 (95% CI)	SEM
Pre-	0.98 [0.96-0.99]	0.06
Session 1	0.97 [0.96-0.98]	0.04
Session 2	0.94 [0.88-0.97]	0.08
Session 3	0.94 [0.88-0.96]	0.06
Session 4	0.98 [0.97-0.99]	0.01
Session 5	0.97 [0.95-0.98]	0.05
Session 6	0.95 [0.91-0.97]	0.05
Post	0.97 [0.95-0.98]	0.03

Effect of the Three Learning Modalities on the Development of Roll backward to handstand: Video recording of Roll backward to handstand of the three groups according to their learning modalities was analyzed on the basis of the five criteria of success of the task previously indicated.

External visual imagery modality

Analysis of the results obtained indicates that the external visual imagery improve Roll backward to handstand execution. Improvement in score means attributed to performers was 4.6 ±0.7 compared with test values 3±1. This explains why external visual imagery learning is an effective method for improving performance (Figure 3).

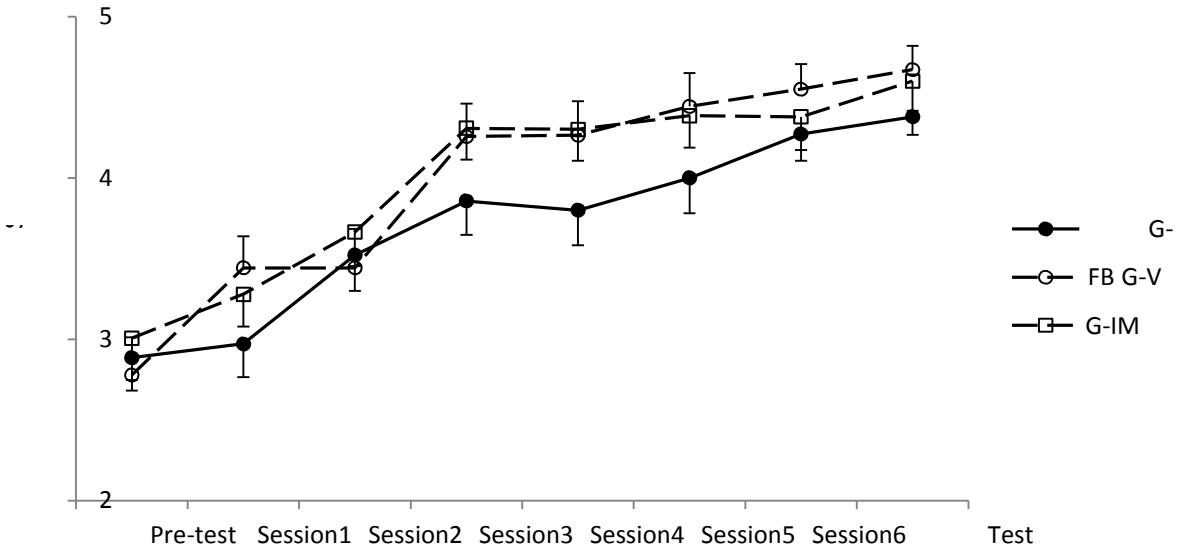

Figure 3. Evolution of the level of learning of the Back Roll to handstand according to learning modalities.

ANOVA analysis revealed that there is a significant effect of the training [F (7; 91) = 25.5; p <0.001; η^2= 0.662] .

Verbal feedback modality

Analysis of the variance (ANOVA) of Roll backward to handstand' performance also revealed that the verbal feedback (FB) either at the beginning or at the end of training revealed a significant effect in terms of performance, as well as in training p <0.001 [F (7.91) = 22.52; $\boldsymbol{\eta}^2$=0.601]. In addition, results indicate that the average performance rating was significantly better in comparison to the predictive scores of 2.9±0.8 to 4.4±0.4 (Figure 3).

Visualization modality

However, visualization modality

contributed to the improvement of scores' mean throughout the learning sessions from 2.8±0.9 to 4.7±0.5 (Figure 3), although Visualization has a significantly lower score compared to other modalities. Results presented in graphic 1 show a significant effect of the training leading to the improvement of technical execution of Roll backward to handstand throughout the cycle as well as the increase in performance obtained.

Technical corrections of gesture and more particularly of mental imagery in the progression of the learning of Roll backward to handstand which vary with each session have a significant effect which was demonstrated by the regression curve which confirms our interpretations. In addition, a progression in the learning of the technique of Roll backward to handstand with verbal feedback' modality was also observed. Moreover, learning through verbal feedback proved to useful in improving technical performance (Figure 3).

General Performance Analysis

ANOVA revealed a significant effect of learning modalities, [F (7; 91) = 22.52; p <0.001; η^2=0.601] for verbal feedback group; [F (7; 91) = 16.62; p <0.001; η^2=0.492] for visualization group; and [F (7; 91) = 25.50; p <0.001; η^2=0.591] for external visual imaging group, although difference between degree of contribution of each one. Although, participants' performance was recorded, their progress during Roll backward to handstand teaching was highlighted. Thus, to illustrate this improvement in performance, an intergroup comparison was used. As shown in Figure 3, with respect to the learning of Roll backward to handstand, ANOVA showed a non-significant group effect as well as a non-significant group interaction of training for F (2; 39) = 1.02; p = 0.37; η^2=0.042] and [F (14; 273) = 0.95; p = 0.51; η^2=0.031) respectively, while a significant effect of training (F (7; 273) = 59.04; p<0.001: η^2 = 0.05].

DISCUSSION

The objective of this study is to determine the role of mental representation during the teaching / learning of Roll backward to handstand.

Potential effect of the imagery, which was clearly identifiable, along with the technical progress was well perceived by the students. Progress recorded by students was particularly improved thanks to an assiduous mental practice and with specific images to the practiced element. These results are aligned with those illustrated by Simonsmeier & Buecke (2016) was showed that imagery is frequently used in gymnastics, and imagery use is positively associated with performance. Also, simulation between mental training by the means of mental imagery and the training of the purely technical movements contribute to achieve the best performance, this result is affirmed by Moraru, Cristiana E. et al., (2015), who showed that the effects of the mental training contribute to the improvement of the technical execution in rhythmic gymnastics and consequently the best results in the competitions. This method is characterized by the fact that the pupil felt like actively implied in the visual performance. Battaglia et al., 2014, Fournier et al., 2005, Smith et al., 2007, confirm the positive effects of imagery procedures have proven to be an effective tool to improve performance in the field of gymnastics. Several conditions allowed an effective use of the mental imagery with high-level athletes.

From an external perspective, the imaging activity was characterized by the fact that the athlete felt actively involved in the visualized performance. Improving the performance of Roll backward to handstand is resulting in an improved motor performance of the same element by the method of external visual imagery. Similarly, technical execution has improved thanks to the improved motor performance since our study element is composed by the association of several

motor actions such as handstand passage. Learning through external visual imagery promoted the stability of the execution of Roll backward to handstand and subsequently improving the technical performance since Handstand is the most important skill in our sport and remaining tight is essential! Gymnasts of all levels perform the handstand several times throughout their workout. While performing many skills in gymnastics, the gymnast must actually pass through the handstand or vertical phase safely and efficiently. Without a good handstand a gymnast may have trouble building skills and therefore progressing through the sports many levels safely and efficiently. These results were confirmed by the work of Jacobson of the neuro-muscular theory (1932) which was one of the first theories explaining the effects of mental imagery on motor performance. Our results were confirmed by the research of Weinberg (1982) which states that visual external imagery should lead to a higher level of performance because it was accompanied by a greater level of muscle activity. In short, results confirm the beneficial effect of the integration of the visual external imagery into a programmer of training in physical education and more particularly in gymnastics compared to the other methods.

Verbal feedback modality

The use of the verbal Feedback method aimed either to improve the performance of the student or to advice around the criteria of success of a gymnastic movement or the errors to be avoided. This helps the student to know his errors and the means to implement to be correct, which allows him by following his training to improve the quality of his performance Giannousi et al. (2017) claim that using verbal cues is very effective, especially for very young children that attempt to learn a new kinetic pattern, especially when verbal cues are linked to practice

Moreover Mrayeh et al. (2015), insisted on the importance of Feedback during or after the completion of the physical task on the improvement of the physical training. As for Schmidt & Wrisberg (2008) reported that feedback is an important variable in the teaching/learning process that can be attributed to motivation in the performance of sports skills of students and athletes.

In short, main results support the idea that the training by the verbal feedback method improves the technical performance of a gymnastic element.

Visualization modality

The method of training by visualization of a model made it possible to associate a video with the element predetermined to provide the learner with the appropriate way to visualize on the laptop the element that he must produce. However, this method appeared to be less developed at the participants in comparison with the mental imagery and the verbal Feedback. Indeed, our results are in conformity with the previous research results, either that was in the sport of high level or in Sport and Physical Education. Merian & Baumberger (2007) state on the basis in the theory of the social training of Bandura that it is possible to learn by observation from a model Baudry et al. (2006) affirm that the video model helps the gymnast to develop a cognitive representation of the movement. This latter would act like an information source and the data that would result from this will be then coded and would make it possible to the observer to build "symbolic notations of the observed behaviors" Baudry et al. (2006, p.55). By viewing the sequences, the subject will analyze the different steps necessary to achieve the performance. It will handle and build, in a way, a way forward to achieve the goal.

Moreover, this learning technique by visualization of a model allows providing information on the student; this will serve later as a reference for the execution or the regulation of his physical actions. According to Magill (2011), the representations put in memory would be used as a guide for the execution of the

movement, but also as standard reference for the detection and the correction of the errors.

CONCLUSIONS

The present study aims at determining the potential effect of the mental imagery on teaching/learning of the gymnastic elements. Thus, visual external imagery seems the best strategy for transmission of knowledge and training as compared to visualization and feedback modalities. Thus, this research opens new prospects as for various scopes of used application. It would be particularly necessary to test other increasingly complex technical elements, apply this method according to the sex and to better standardize the conditions of mental work practice. Consequently, this work aims mainly to clear up, drive awareness and inform in some ways the teacher about these new methods and by hoping that such a reading gives desire to certain teachers to go further in their reflections, their trainings and their practices. Therefore, gymnastics is an individual sport with few external factors, and therefore both the mental and physical states of the gymnast are by far the most important factors influencing the success of a performance. Implementing sport psychological skills is thus an important tool for coaches as well as gymnasts to optimize the mental state of the athlete.

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THE POST ACTIVATION POTENTIATION EFFECT OF TWO DIFFERENT CONDITIONING STIMULI ON DROP JUMP PARAMETERS ON YOUNG FEMALE ARTISTIC GYMNASTS

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Original article

Abstract

The purpose of this study was to examine the post activation potentiation (PAP) effect of two different conditioning stimuli (CS) on drop jump (DJ) parameters on young female gymnasts. Thirty young female artistic gymnasts, aged 8 to 13 years old performed two protocols of either double tuck jumps (DTJ: 2 sets of 5 repetitions) or legs blocking action (LBA: 2 sets of 5 repetitions) in a within-subject randomized design. Before and immediately after the PAP treatment and 4, 8, 12, and 16 min after, jumping ability was measured by performing a drop jump (DJ). Statistical analysis revealed significant interaction effect between the two CS for DJ height ($p < 0.002$), time flight ($p < 0.002$) and take-off velocity ($p < 0.003$). Furthermore, significant main effect was found for protocol on DJ height ($p < 0.001$) and time flight ($p < 0.001$). It is recommended to the sports experts to include similar condition stimuli in the warm-up procedure, in order to improve their jumping performance. Conclusive both CS cause PAP phenomenon but the specialized CS produces higher rates of improvements in young female artistic gymnasts.

Key words: *plyometric exercise, artistic gymnasts, drop jump.*

INTRODUCTION

The majority of women gymnastics' routines are characterized by the use of lower limbs as in vaulting, balance beam and floor exercises. When training for these routines the gymnasts perform a great number of rebound jumps (more than 1000 per week) (Marina et al., 2012). Rebound jumps are characterised by the Stretch Shortening Cycle (SSC) and require high muscle strength and power**.** As Malisoux and colleagues stated, SSC exercises such as drop jumps can induce neuromuscular adaptations to the stretch reflex, elastic energy of the muscle and Golgi tendon

organ desensitization (Malisoux et al., 2006) and have been used as an intervention to examine the acute effect on muscle performance (Hilfiker et al., 2007; Masamoto et al., 2003). Furthermore, gymnasts, in order to improve their power production (Marina & Jemni, 2014) include in their warm-up skills that physically prepare them to perform the acrobatic series that will follow, such as forward/backward salto, acrobatic combinations etc.

A new technique used to induce a short-term increase in strength and power during training or competition is post activation potentiation (PAP) (Robbins, 2005). PAP is the phenomenon where previous intense muscle contractions increase subsequent force and power output over the baseline level (Sale, 2002). Special exercises included during warm-up, before training or competition may cause a PAP phenomenon that results in increased performance in the main activity as a result of strength conditioning exercises followed by dynamic exercises with similar motives of movement (Gouvea et al., 2013). Previous findings support that these plyometric exercises enhance muscle strength and power (Hilfiker et al., 2007; Masamoto et al., 2003) concluding that plyometric raise the motor unit efficiency (Esformes et al., 2010; Margaritopoulos et al., 2015; Saez Saez de Villareal, 2009) which in turn results in an increased neural stimulation of the muscle and improved subsequent power production (McBride et al., 2005). There are several proposed mechanisms responsible for the PAP phenomenon which are related a) to the phosphorylation of myosin regulatory light chains (Baudry & Duchateau, 2007; Ryder et al., 2007; Sale, 2002), b) the increase in the recruitment of motor units and the relative changes in muscle stiffness (Suchomel et al., 2016) and c) the changes that result in muscle's pennation angle (Mahlfield et al., 2004).

Previous findings support that several factors such as training status (Rixon et al., 2007), the type of the condition stimulus (CS) [maximum isometric contractions] (Tsolakis et al., 2011) and the type of muscle fibers (Sale, 2002), the exercise characteristics (intensity, specificity, volume) (Killduff et al., 2007; Steele et al., 2013; Tillin & Bishop, 2009) and the duration of rest intervals (Gouvea et al., 2013) may affect the magnitude of the PAP effect. Different types of muscle contraction at maximal or sub-maximal (Chatzopoulos et al., 2007; Killduff et al., 2007) levels have been used as potentiating exercises to improve lower limbs performance in various tasks (Hilficker et al., 2007; Till & Cooke, 2009).

Marina et al. (2012) examined the factors influencing drop jump (DJ) performance between well-trained gymnasts and a control group (aged 9-20 years) using different DJ heights from 20 up to 100 cm and found that the best performances were obtained between 40 cm and 60 cm drop height for both groups. However, the control group revealed a trend towards a continuing decline in DJ performance with the increase of the drop height. Dallas and Kirialanis (2013) who examined the effect of different conditions of Whole Body Vibration (WBV) with or without stretching on squat jump (SJ) and counter movement jump (CMJ) performance of well-trained artistic gymnasts with a mean age of 21.88 years, found no significant differences in jumping performance. However, the percentage improvement of WBV was greater in SJ and CMJ variables compared to WBV combined with static stretching (WBVSS condition immediately after the CS with this effect lasting up to 15 min in SJ performance. Furthermore, Dallas et al... (2014) investigated the acute effect of a single bout of WBV on SJ, CMJ and single leg explosive strength of young gymnasts with a mean age of 9.22 years. Results showed an improvement in SJ performance immediately after the end of the intervention stimulus with this effect lasting for about 15 min following the end of the intervention stimulus. Tsopani et al. (2014) who examined the effect of WBV on balance, flexibility and jumping performance on elite rhythmic gymnasts found an improvement

in SJ, CMJ and single leg jump performance immediately after the end of the stimuli which in turn became greater 15 min later. However, no study has investigated the acute effect of specific CS on PAP. Thus, it is not clear which athletes may benefit from this phenomenon. If PAP depends primarily on muscle strength, then subjects with similar muscle strength but different CS should experience the same effect of PAP on performance.

A limited number of studies (Arampatzi et al., 2014; Hilfiker et al., 2007; Marina et al., 2012) examined the PAP phenomenon on gymnastics with most of them using as CS the DJ or CMJ. Their findings were contradictory. Specifically, the results of Hilfiker et al. (2007) who examined the effect of 5 modified drop jumps on SJ and CMJ performance in athletes of various sports (ski & gymnastics) with a mean age of 22 years, showed a consistent tendency for improvement when adding drop jumps to a warm-up routine compared to a warm-up without drop jumps, and of Marina et al. (2012) who investigated the factors influencing plyometric jumping performance and also showed improvement in DJ height. However, data of Arampatzi et al.. (2014) who examined male and female participants of three different age groups (pre-adolescents: 10-12, adolescents: 14-15, and adults: 20-25 years old), using maximum half-squat isometric contractions, revealed that the conditioning stimulus significantly increased SJ performance in men but has no effect on jumping performance in teen-males, boys and in females irrespective of age. However, none of them used the plyometric exercises that gymnasts incorporate in their training sessions. Taking into consideration the results of the above mentioned studies it remains unknown whether the CS may improve the performance of jumping ability in pre-adolescent female gymnasts. There are no scientific findings comparing plyometric exercises of different forms (typical - specific). So, it is not certain which form of plyometric stimulus (PS) causes the greatest PAP effect. Thus, the purpose of this study was to examine the acute effect of a specific (leg blocking action: LBA) and a typical (double tuck jumps: DTJs) conditioning stimulus immediately after the PAP treatment and following 4, 8, 12, and 16 min, on explosive strength of lower limbs on drop jump (DJ) performance in young female gymnasts. It was hypothesized that specific form of CS would have a greater PAP effect.

METHODS

Thirty moderate trained female artistic gymnasts, aged 8 to 13 years old (Tanner stage 1-2) (Tanner, 1962) (age = 10.10 ± 2.17 years, body weight = 33.99 ± 8.91 Kg, body height = 135.93 ± 11.69 cm, body mass index [BMI] = 18.06 ± 2.23, training experience = 17.53 ± 11.92 months) volunteered to participate in this study. All subjects were familiar with the exercises used (LBA, DTJ, DJ) as they were part of their daily training practice. Institutional Ethics Board, and all procedures were in accordance with the ethics of University of Athens approval was obtained and all subjects' parents gave written informed consent before participating in any of the testing. The subjects were informed extensively about the experiment procedures and the possible risks or benefits of the project, had no musculoskeletal injuries in the previous 6 months.

This study was designed to investigate the effect of PAP on lower limbs explosive strength in young female gymnasts. More specifically, a repeated measure, within subject randomized design, involved 2 different CS: a typical CS (double tuck jumps: DTJs) and a specialized CS (legs blocking action [LBA]) was used to evaluate the effects of PAP on jumping performance. Furthermore, in order to evaluate the fatigue and PAP interactions on lower power output, the performance tests were executed immediately following the interventions and were repeated every 4 min up to 16 min.

All testing sessions took place during a 2-week period. The subjects were examined

in their training hall during three different sessions. During the 1st session the anthropometric characteristics of subjects (age, body mass, body height) were measured and a familiarization session was performed to get acquainted with the proper technique for the execution of LBA and DTJ. On the 2nd and 3rd session, following a five-minute warm-up that included low intensity running with callisthenic exercises the subjects performed DJ baseline performance tests (Pretest) using the Chrono jump mat (Bosco et al., 1983). Two trials were performed and the best score was considered for statistical analysis. Drop Jump height (DJH), Flight Time (FT), and take-off velocity (V) of the DJ were considered as the dependent variables and were used in the subsequent analysis. The rise of the centre of gravity above the ground (h in m) was measured (Bosco et al., 1998) from flight time (tf in seconds) applying ballistic laws: h = tf2 . g . 8-1 (m), where g is the acceleration of gravity (9.81 m . s-2). The subjects performed two DJ from a 33-cm box with hands placed on their hips throughout the test and they were instructed to jump, as soon as possible, trying to minimize the time of contact with the floor. Thirty seconds recovery was given between each DJ. Their knees and ankles had to be fully extended when leaving the box. The reliability for the DJ height was estimated to be 0.96 ($p < .001$).

Following the warm-up and baseline measures, each subject performed a conditioning protocol (PAP) that consisted either of 2 sets of 5 repetitions of the legs blocking action on the feet or 2 sets of 5 double tuck jumps with a 30 seconds interval between sets. The DTJ were performed by explosively jumping upward while quickly pulling the knees to the chest. In the LBA, each subject, from standing position, performed a step forward followed by a leap and a rebound with two feet after landing (stop jump), an action which is similar to that used by gymnasts in order to perform a forward salto on the floor event following the preparatory running phase. In order to evaluate the fatigue and PAP interactions on DJ output the performance tests were executed immediately after the interventions and were repeated every 4 min up to 16 min with a rest period of 30 sec between trials. All testing was conducted at the same time of the day (18.00-20.00) to eliminate a possible time-of-day effect, and a minimum of 72 hours was provided between hall visits. Subjects were familiar with the PAP condition stimuli (LBA & DTJ].

For the measurement of lower-body performance subjects performed a DJ. The Intraclass correlation (ICC) for the peak power output during the DJ tests was 0.97 ($p < 0.001$). The plyometric PAP activities were the DTJ and LBA. Subjects performed 2 set of 5 repetitions of these drills with 30 sec rest between each effort. These plyometric drills which result in high muscle fiber recruitment (Till & Cooke, 2009) are empirically used by gymnasts as part of their warm-up to improve their performance during training.

The IBM Statistical Package for the Social Science (SPSS) (version 21) was used for the statistical analysis. The arithmetic mean, standard deviation, and range were calculated for each variable and trial. Raw data were checked for normality using a Shapiro–Wilk test as the sample size was < 50. To explore the impact of time (pre, post1, post4, post8, post12, and post16) and CS (LBA, DTJ) on the dependent variables, a two-way (group x time) ANOVA with repeated measures on the second factor was used for the statistical analysis. Sphericity was checked using Mauchly's test, and the Greenhouse-Geisser's correction on degrees of freedom was applied when necessary. Levene's test of equality of error variances was used to check the assumption of homogeneity of variances. In cases where interaction between time and group was detected, the simple effects were investigated, and Bonferonni's correction was used. In the absence of interaction, the main effects of the two factors (measurement and protocol) on the dependent variables were

investigated. All statistical significances were tested at $\alpha = 0.05$.

RESULTS

The Drop jump height (DJH) results indicated a significant interaction effect between the two factors ($F_{(5)} = 5.379$, $p < 0.002$, $\eta^2 = 0.518$). Furthermore, significant main effect was found for protocol ($F_{(1)} = 21.476$, $p < 0.001$, $\eta^2 = 0.291$). The post hoc analysis revealed that there was significant difference in the LBA protocol between post 1 (immediately after), post 8 and post 12 compared to baseline values. On the contrary, significant differences were found in the DTJ protocol between post 1 (immediately after), and post 8 compared to baseline values (table 1).

Table 1

Time course comparative analysis between interventions (LBA - DTJ) in drop jump height (DJH), time flight (TF) and take-off velocity (V) performance on gymnasts (n = 30).

		Time					
		PRE	POST 1	POST 4	POST 8	POST 12	POST 16
DJH (cm)	LBA	20.03±5.09	22.39±5.47*	20.89±5.38#	21.34±4.75*#	21.46±5.07*	20.80±5.03#
	DTJ	19.67±4.94	22.28±5.23*	20.69±5.11#	20.70±4.52*#	20.64±4.83#	20.20±4.73#
TF (ms)	LBA	0.40±0.05	0.42±0.05*	0.41±0.06#	0.41±0.04*	0.41±0.05*	0.41±0.05#
	DTJ	0.40±0.05	0.42±0.05*	0.40±0.05#	0.41±0.04*#	0.41±0.05*#	0.40±0.05#
V (m/sec)	LBA	1.97±0.25	2.08±0.25*	2.01±0.25#	2.03±0.22*	2.04±0.24*	2.00±0.24#
	DTJ	1.95±0.25	2.07±0.25*	2.00±0.24#	2.00±0.22*#	1.99±0.23*	1.98±0.23#

Significant differences from baseline, p = 0.05; # Significant differences from post 1, p=0.05; LBA :Leg blocking action, DTJ: Double tuck jumps.

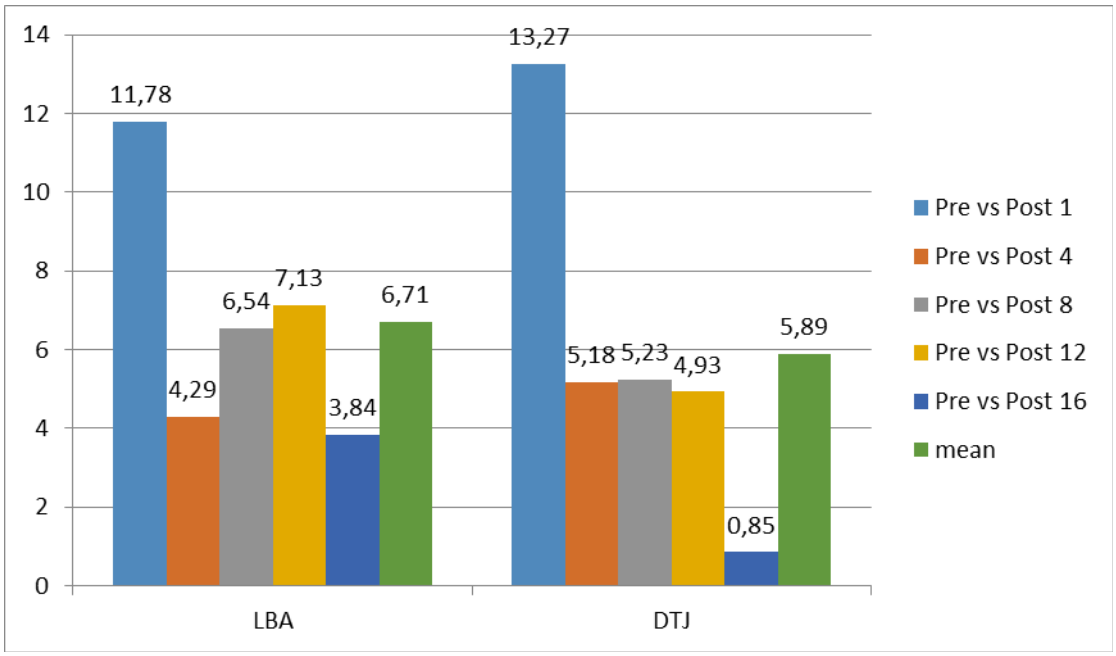

Figure 1. Percentage (%) improvement in post measurements compared to baseline values (pre) in gymnast's drop jump height between two different condition stimuli.

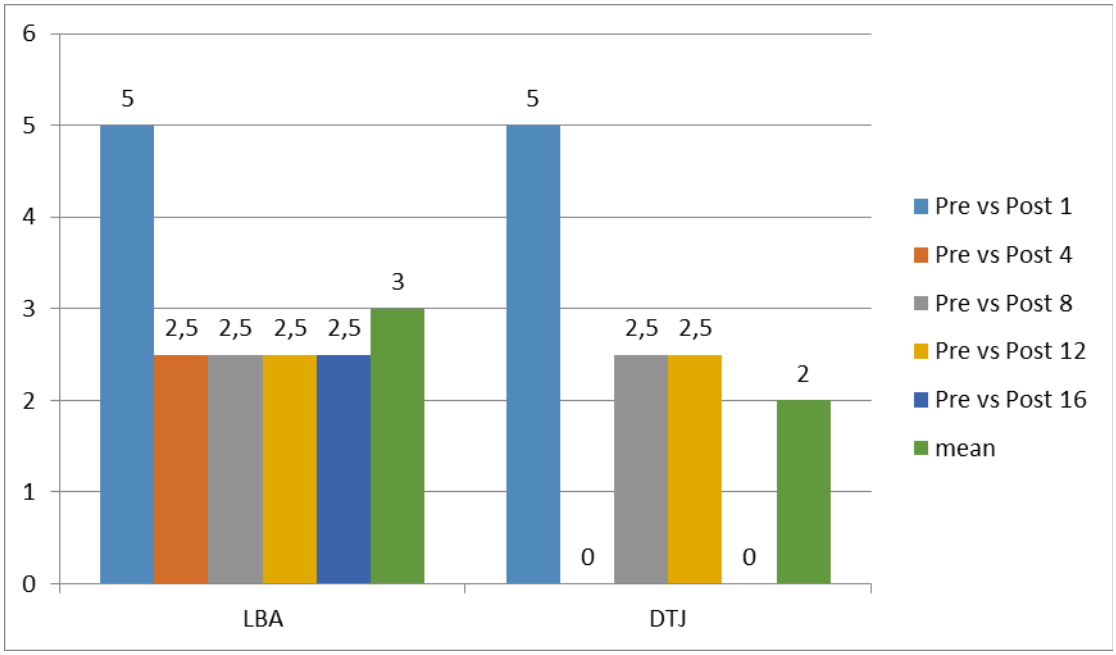

Figure 2. Percentage (%) improvement in post measurements compared to baseline (pre) values in gymnast's time flight between two different condition stimuli.

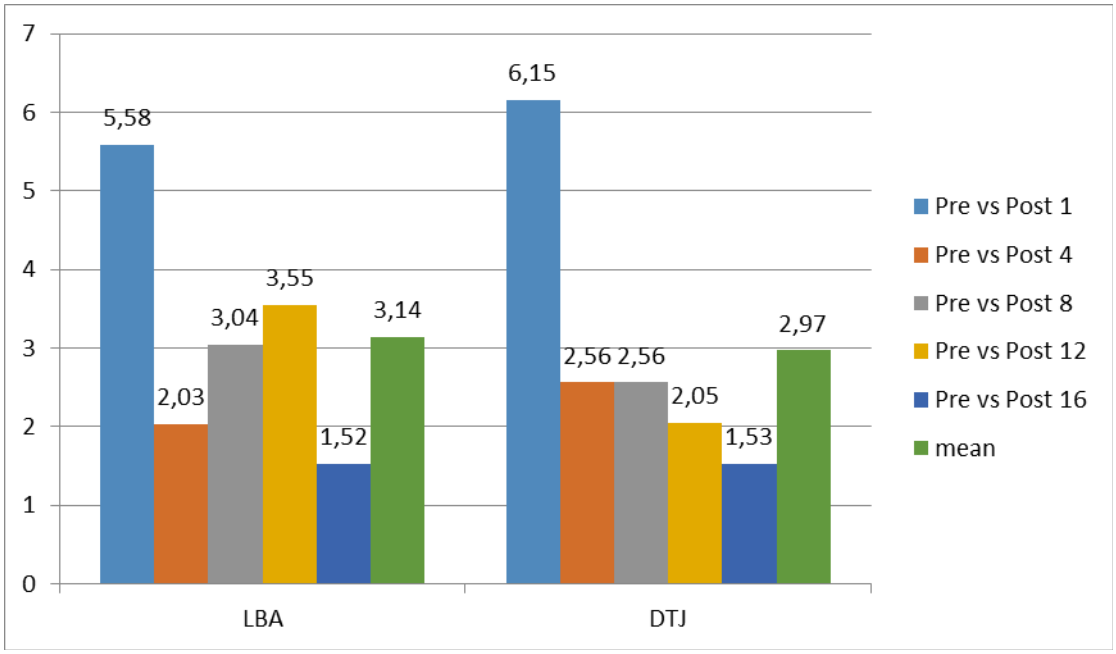

Figure 3. Percentage (%) improvement in post measurements compared to baseline (pre) values in gymnast's take-off velocity between two different condition stimuli

Moreover, the mean percentage improvements compared to baseline values (pre) in gymnast's drop jump height was greater in the LBA protocol compared to the DTJ protocol (figure 1).

Significant interaction effect was found for flight time (TF) ($F(5) = 5.219$, $p < 0.002$, $\eta 2 = 0.511$). Furthermore, significant main effect was found for protocol ($F(1) = 24.903$, $p < 0.001$, $\eta 2 = 0.462$). The post

hoc analysis revealed that there was significant difference in the LBA protocol and DTJ protocol in post 1 (immediately after), post 8 and post 12 compared to baseline values ($p < .05$) (table 1). Moreover, the mean percentage improvements (%) compared to baseline values (pre) in gymnast's drop jump flight time was greater in the LBA protocol compared to the DTJ protocol (figure 2).

There was significant interaction effect between time and protocol for take-off velocity (V) ($F(5) = 4.969$, $p < 0.003$, $\eta 2 = 0.498$). Significant main effect was found for protocol ($F(1) = 18.187$, $p < 0.001$, $\eta 2 = 0.385$). The post hoc analysis revealed that there was significant difference in the LBA and DTJ protocol in post 1 (immediately after), post 8 and post 12 compared to baseline values ($p < .05$) (table 1). Furthermore, the mean percentage improvements compared to baseline values (pre) in gymnast's take-off velocity was greater in the LBA protocol compared to the DTJ protocol (figure 3).

DISCUSSION

This is the first study that examined the effect of a specific (LBA) or a typical (DTJ) CS on drop jump parameters (height, flight time, take-off velocity) at recovery times of 15 sec – 16 min on young female gymnasts. The main finding of the present study was that: (i) both protocols revealed a trend for increased positive effects on DJ parameters; ii) there was a trend for different pattern of CS-time effect on DJ performance between the LBA (specialized) and DTJs (typical) protocol. Our results revealed that short-duration and high intensity dynamic exercise (LBA) elicits a different drop jump height post-activation potentiation (PAP) effect when compared to the typical DTJs (medium-intensity contractions). The volume of the CS applied in our study (2 set per 5 repetitions) may increase the excitability of motor units (Kilduff et al., 2007; Masamoto et al., 2003) and further offer sufficient recruitment of fast-twitch muscle fibers, thereby improving DJ performance in young female gymnasts (Sale, 2004; Till & Cook 2009; Tsolakis et al., 2011).

LBA intervention resulted in greater improvement in DJ parameters in post measurements (15 sec – 16 min) after the end of intervention compared to DTJs intervention. The magnitude of improvement in DJ height by the LBA (3.84 % - 11.78%) and the DTJs (0.85 % - 13.27 %) suggests that explosive-typing loading used in our study facilitates the function of the neuromuscular system without causing undue fatigue resulting to the improvement of the fast-twitch units (Linnamo et al., 1998). Nevertheless, it is underlined that the average increase in post measurements in each parameter considered was the largest specialized stimulus compared to the typical. In our study, the improvement in DJ parameters (height, flight time, take-off velocity) suggests that a series of plyometric exercises, 10 repetitions, appears to be an efficient method of taking advantage of the PAP phenomenon and supports other findings (Arampatzi et al., 2014; Lowery et al., 2012) that examined the effect of plyometric exercises on explosive strength of lower limbs. Furthermore, previous studies found that 5 DTJs (Till & Cooke, 2009) have no significant differences between the conditions in sprint and vertical jump performance or multiple sets of DTJs 3x3 (Turki et al., 2011) or 3x5 (Tsolakis et al., 2011) have no effect on subsequent plyometric performance over 12 - 20 min respectively. In contrast, other findings revealed that 3-10 single repetitions of DJs can improve lower extremity power performance by 2.4% up to 3.5% (Hilfiker et al., 2007; Masamoto et al., 2003). It seems that the level of intensity of the stimulus affects the interaction between fatigue and PAP, thus determining subsequent performance (Suchomel et al., 2016). Post activation potentiation is defined as a phenomenon by which previous muscle activity contributes to enhancing the muscle power and the performance of subsequent activity (Hamada et al., 2000). Following multiple sets of potentiating

exercises, recovery periods of more than 3 min are necessary to elicit a PAP effect and to increase subsequent performance (Wilson et al., 2013).

Immediately following both interventions, the percentage performance improvement of the present study suggests that using high-intensity contractions such as LBA, or medium-intensity contractions such as DTJs during a warm-up, elicit a PAP effect that may positively affect jumping performance (Ebben 1998; Gullich & Schmidtbleicher, 1996). LBA is a specific competitive explosive activity that may load various large muscle groups to a greater degree than DTJs which are considered to be medium-intensity exercises. The percentage improvement found in our study is comparable with data of Tobin and Delahunt (2014) who reported an improvement by 4.8%, 3.9%, and 3.5% at 1, 3 and 5 minutes post-plyometric exercise respectively on CMJ performance on rugby athletes aged 22.4 ± 3.4 years. However, our results oppose previous data of Bassa et al.. (2012) who examined prepubertal trained and untrained boys and girls, aged 9-11 years, and found no performance gain, during SJ, CMJ and DJ from height up to 50 cm, although trained children (irrespective of gender) showed a higher performance compared with the untrained ones. Several factors such as the volume of the preload stimulus, gender, duration of the rest intervals between the consecutive sets and before execution, may be responsible for the equivocal findings among the aforementioned studies. These plyometric stimuli were chosen because they are empirically used by young gymnasts as part of their warm-up and strength programs. In a meta-analysis, Wilson et al.. (2013) have noted that windows of approximately 3-7 min reveal significantly greater potentiating effects compared to intervals longer than 10 min. The results of our study concerning the DTJs protocol revealed a PAP effect immediately after and up to 16 min of rest, a finding that verify data of previous studies that found PAP effect immediately after and up to 12 min (Chen et al., 2013). Ebben and colleagues reported that fast-twitch muscle fibers should be sufficiently recruited during the plyometric stimulus (LBA or DTJs) (Ebben et al., 2008). The intensity of the CS used in our study may increase the excitability of motor units (Kilduff et al., 2007) resulting in improved DJ performance and, in addition, provide adequate recruitment of fast-twitch muscle fibers (Sale, 2004).

CONCLUSIONS

In conclusion, the findings of the present study indicated that different forms of plyometric drills (specialized [LBA] or typical [DTJs]) that are used as part of warm-up exercises provide an advantage in DJ performance in the acute phase (15 sec – 16 min) after the completion of the CS exercises in young female gymnasts. Furthermore, taking into consideration that specialized plyometric exercises may produce a greater PAP effect, it is useful to incorporate them into the warm-up especially prior to competitions in order to retain this PAP effect for as long as possible. Our study has some limitations. We examined thirty moderately trained female gymnasts; therefore, generalizations should be treated with caution. Furthermore, DJ height and take-off velocity (V) were calculated based on the flight time measurement.

The findings of this study have significant implications when considering the application of plyometric exercises to exploit the PAP phenomenon. The results support that the utilization of a specific (LBA) or a typical (DTJ) plyometric exercise causes an immediate improvement on DJ parameters (height, flight time, take-off velocity). Hence, for gymnasts competing in floor exercises or in vaulting, events that incorporate a specialized warm-up motor skill are likely to lead to a potentiating effect on performance with minimal fatigue. Condition stimuli exercises may be performed by pre-adolescent gymnasts, however, the intensity of these

exercises should vary depending on the level of their muscular strength.

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SYSTEMATIC REVIEW OF YURCHENKO VAULT KINETIC AND KINEMATIC INDICATORS

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Review article

Abstract

The aim of this article was based on determining the most relevant kinematic indicators in the Yurchenko vault technique, using the mechanical purposes of each phase as linking elements. A systematic qualitative review was carried out with an initial search of 67 scientific documents, of which 27 were selected by matching the Yurchenko key words, kinetic, kinematic and artistic gymnastics and their respective combinations. It was concluded that the main kinetic and kinematic indicators involved in this vault are: acceleration, speed, distance, displacement, trajectory, contact time, flight time, percentage of deformation and angular momentum that exert on the center of mass. The following article is proposed as a study instrument to guide in the correct direction of kinetic and kinematic factors to be considered in the effective execution of the Yurchenko vault technique.

Key words: *yurchenko, kinetic, kinematic, center of mass, vault, gymnastic.*

INTRODUCTION

In Artistic Gymnastics (AG), the Yurchenko vault is performed by men and women, which is categorized within the vaults originated from the round-off, with or without 3/4 of turn in 1st flight and back flip with or without turn in the 2nd flight; this sports skill consists of the execution of three gymnastic elements: rondat with ¼ turn, flic-flac and backward rewinding vault (Federation International Artistic Gimnastic, 2017).

Since the inclusion of Yurchenko into the score code of AG, this exercise has been one of the most ambitious and complex to perform by gymnasts in the vault mode, for both men and women (Carrara, 2009). Its correct execution guarantees a high score value from the judges, because it requires a greater difficulty when combining acrobatic elements, with or without hands support as well as a 2nd phase of flight.

This vault, in AG is the only element that offers a deeper analysis, because it implies the execution of more than one acrobatic element (Prassas, Kwon, & Sands, 2006), which expresses a certain level of

complexity and exigency in the precision and cleanliness of the execution. Among its kinematic characteristics, this vault encompasses a series of rotational and linear movements demanding speed and inertia for the continuity of the movement (Jemni, 2013). However, as all the vaults, the key of the success is in the approach and the pre-flight (Uzunov, 2010), moreover, the specific characteristics of post-flight must have a differentiated training (Takei, 2007). This is how it is noticed that to develop a correct technique, three key characteristics must be prioritized: a) center of mass speed during the pre-flight; b) angular momentum of the pre-flight; and c) angular velocity and pushing force in the repulsion (Penitente, 2014).

It requires an understanding in each of the phases of this sports technique (ST), which are segmented by its particular objectives. Currently, the ST study should generate more analysis than just the pedagogical study (Aedo-Muñoz & Bustamante-Garrido, 2012), which is used mainly in the transmission of the phases that compose the ST, omitting essential information to orient optimally towards a technical objective.

The ST should be understood as a sequence of organized movements oriented to the resolution of a specific motor task, according to the rules of competition (Barrios & Ranzola, 1999;Bermejo, 2013). The ST has the obligation to have an overall performance goal (GPO), which corresponds to its main characteristic involved in the fulfillment of this motor task (Morante & Izquierdo, 2008); thus each ST with its respective GPO are divided into phases that have a single mechanical purpose (MP), which refer to the mechanical or muscular characteristic that implies to enforce at each stage. Each MP originates its biomechanical indicators (BI), also called biomechanical targets (BT) and these correspond to all the kinematic indicators (Klm) and kinetic indicators (Kln) derived from the MP. Klm being our object of study, it should be mentioned that these aspects can be evaluated by the biomechanics of sport emphasized in the study of movement, regardless of the causes that could modify it (Ibañez, Martin, & Zamarro, 1989; Aedo-Muñoz & Bustamante-Garrido, 2012).

The purpose of this article is to identify the Klm and KIn involved in the MPs of the Yurchenko vault technique, as a way to highlighting the importance of the biomechanical study within the GA, which provides the keys for the performance in this discipline, for this reason it was considered relevant make a searching in a priority way of the kinematic variables that intercede in this type of vault, in order to provide concrete tools that follow a pedagogical guideline specialized in their teaching.

METHODS

A qualitative systematic review of the kinematic characteristics was carried out in relation to the ST phases and their respective MP. We used information sources from the last 20 years, for instance: Journal Science of Gymnastics, Journal International Sport of Biomechanic, Research Gate, Scielo and Dialnet, PubMed, Sciencedirect, SportDiscus, Elsevier, Medline, Web of Science, considering key words and combinations attributed to: "yurchenko", "kinematic", “kinetic” and "artistic gymnastics". It is worth mentioning that studies linked to some of the categories were excluded: studies published in a summary form and/or short communications, not written in English or Spanish, and those that, in rigor and formality, did not agree with characteristics necessary for this review.

In order to reach this purpose, an initial search of 67 documents in databases was managed, and 17 documents in texts, none of them were in duplicated. Browsing the publications, 41 were projected, 17 were excluded because did not contain kinematic criteria of interest for this study. 18 articles were selected and 23 articles were exempted from the review for not offering a finished study of the subject. Applying the criteria

mentioned above, 27 studies were used to carry out this qualitative research. From the selected references, the following article of review was constructed to describe and analyze the kinematics of the Yurchenko vault.

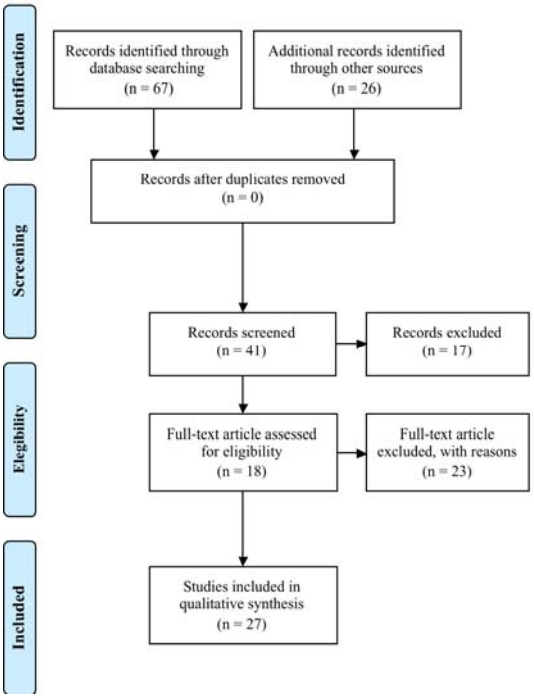


Figure 1: Flow chart of the review.

RESULTS

The GPO of the Yurchenko vault is a quick approach and an energetic repulsion in the pre-flight phase (Uzunov, 2011). Within many proposals of the phases of this ST, the most standard one divides the technical gesture into two phases: 1st flight and 2nd flight, from which the sub-phases emerge (Boldrini et al., 2016). In the individuality of its study, each phase shows MP that for its correct execution requires the knowledge of their respective Kim.

Figure 2. Yurchenko Vault Sequence (Boldrini et al., 2016)

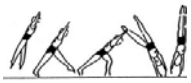
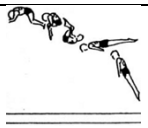
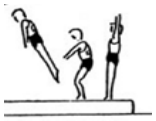
1st flight Subphase 1.1: **Run** Generate enough speed and stroke control (Federation International Artistic Gimnastic, 2017) MP: comfortable approach speed KIm: Speed and run distance.	
Subphase 1.2: **Round-off** Maintain the COM close to the ground to eliminate decelerations and allow greater trunk rotation (Uzunov, 2011). MP: Keep COM near the ground KIm: Trayectory of COM and angle relative rotation trunk. Horizontal displacement COM: 1,61±3 m. Vertical displacement of COM: 11±3 height%(Young-Kwan & Cheol-Hee, 2017)	
Sub-phase 1.3: **Springboard Support** Approximation of high impact angle - 60 ° in both angles - with minimal hip flexion and knees (Boldrini et al., 2016). MP: accumulation of elastic energy KIm: Percentage deformation springboard, Contact time with springboard, flight time and horizontal COM displacement. Contact time: 0.13±0.02 seconds Horizontal displacement COM: 0.57±0.08 m. Vertical displacement of COM: 36±5 height% Flight time: 0.12±0.02 seconds (Young-Kwan & Cheol-Hee, 2017)	
2nd flight Sub-phase 2.1: **Table Vault Support** Show a quick flex shoulders above 180 ° to touch the table through a powerful push to quickly deflect the vaulting table (Koh, 2007). MP: Energy elastic contact. KIm: Speed of COM, angle relative shoulder flexion, contact time with the table and table deformation porcentage. Contact time: 0.22±0.02 seconds COM horizontal speed: 3.0±0.045 m/s (Young-Kwan & Cheol-Hee, 2017)	
Sub-phase 2.2: **Back Flip** Started off the table, chest hides and lowered his hands to help accelerate rotation (Uzunov, 2011). MP: Accelerating rotation KIm: Angular acceleration *(a<º)*, Bending angle relative coxofemoral *(<ºcoxof)* and Flight time (*ft*).	
Subphase 2.3: **Landing** Watching the landig mat through both feet accurately. Keep your arms extended in front and legs in squatting position (Requejo et al., 2004). MP: COM KIm: COM and support base relationship.	

Figure 3. Yurchenko phases with Mecanic Purposes (MP) and Kinetic (KIn) and Kinematic indicators (KIm).

Table 1
Review summary table.

No.	Author	Sample	Method	Under study	Result
1	(Aedo-Muñoz & Bustamante-Garrido, 2012)	13 items	Qualitative literature review.	Conceptualisation of biomechanics	Tasks of biomechanics in sport are: Describe sports techniques., correct defects sports technique, propose more efficient and effective techniques.
2	(Aldazabal, 2010)	Does not have	Qualitative research method and quantitative	Kinetics	Kinetic analysis vault.
3	(Araújo, 2004)	Does not have	Qualitative research method	Artistic gymnastics	Mechanical aids in gymnastics.
4	(Barrios & Ranzola, 1999)	Does not have	Qualitative research method	Biomechanics	Manual initiation to the sport.
5	(Bermejo, 2013)	46 books, 26 articles and 2 theses	Qualitative literature review	Biomechanics	Sports technique is an ideal movement on sport and the athlete, it runs a sequence of logical pattern established based on internal and external sport and depending on prior knowledge in mechanics and practical experience rules.
6	(Boldrini, Carrara, Serrao, Amadio, & Mochizuki, 2016)	40 items with variables hand and vault	Qualitative literature review	Kinetic energy and potential energy	During preparation, the gymnast runs to increase the kinetic energy and increase mechanical linear and angular rotations to be held in the 2nd flight energy.
7	(E. Bradshaw, Hume, Calton, & Aisbett, 2010)	13 Australian high performance gymnasts	Feedback system as gymnastics vault	Speed and contact time	Speed measurements of contact with an integrated plate punch carpet, can be used reliably to assess vault in gymnastics.
8	(E. Bradshaw, 2004)	5 gymnasts Elite 13 to 15 years	2D capture system	Kinematic variables	Include exercises that improve the ability to run, vault during execution.
9	(E. J. Bradshaw & Sparrow, 2001)	5 trials for 5 gymnasts	2 reference strips were placed with alternating intervals of 50cm in black and white, on each side of the approach area over a raised platform for two qualified judges.	Diving important variables	A faster approach leads to an increase of the speed of rounding ($p \leq 0.01$), resulting in a rapid and short take-off table ($p \leq 0.01$).
10	(Carrara, 2009)	8 coach of the senior category of national teams - Portugal and Brazil	Descriptive statistics (mean and standard deviation) and inferential statistics (Mann-Whitney).	WAG Code 2001 y 2006 ,	Physical preparation, increased volume and intensity of training occurred; in the Technical Preparation, a greater variety of elements of the different groups was necessary; in the Tactical Preparation, the exercises with the greatest number of elements of greater difficulty are verified,
11	(Estapé Tous, 2002)	Does not have	Qualitative research method.	Acrobatics	Technical analysis of the vault.
12	(Federation International Artistic Gimnastic, 2017)	International levels	Method of experts and approved by the Executive Committee FIG, updated after Intercontinental Judges Course GAF (12 to 18 / Dec / 2016).	Code of Points in artistic gymnastics	Code of Points for Olympic Games, World Championships, regional and intercontinental competitions and events with international participants.
13	(Hassan, Hanna, & Ameen, 2015)	40 students University of Diyala	Method experiment using quasi-experimental design through a diving platform.	Biomechanics of vault	The theoretical biomechanical information they gave students a positive impact on their ability and performance, through the vault platform.

14	(Hedbávný & Kalichová, 2015)	14 gymnasts from 18 to 25 years	Method 3D kinematic analysis.	Speed	With the maximum speed in the take-off phase springboard, the athlete is able to better use the technique in order to properly execute the entrance to the vaulting table.
15	(Ibañez et al., 1989)	Does not have	Quantitative research method.	Physical variables	Kinematic analysis.
16	(Izquierdo, Echeverría, & Morante, 2008)	Does not have	Method of qualitative and quantitative research.	Biomechanics	Biomechanical analysis on physical activity.
17	(Jackson, 2010)	1 gymnast	A simulation model was developed in the phase contact with the table vaulting in gymnastics.	Kinematic vault	The angular momentum always decreased during the contact with the vaulting table, although the reductions were smaller when the rotation is maximized after the flight.
18	(Jemni, 2013)	Does not have	Quantitative research method.	Physical variables	Analysis of kinematics and kinetics in gymnastics.
19	(Koh, 2007)	1 gymnast	Experimental method through combined selection of parameters.	Kinematics	The angle of attack on the vaulting table remained low and previous angular momentum flight had to be increased with higher profits.
20	(Mkaouer, Jemni, Amara, Chaabene, & Tabka, 2013)	5 gymnasts high level	Through a platform synchronized force with a system of two-dimensional analysis to collect kinetic and kinematic data.	Kinematic and kinetic vault	Highest elevation of COM in the flight phase improves the performance and enliven the risk of falls. The optimal number would be rondat, flic-flac to vault in extension, which would better vault height.
21	(Penitente, 2007)	14 gymnasts	Experimental method through 3D coordinate system.	COM Kinematics	Gymnasts use the board to prevent large decrease of the horizontal speed of COM and increase the vertical speed of this.
22	(Penitente, 2014)	16 Italian gymnasts	Experimental method through deterministic model.	Kinetics phases Yurchenko	The post-flight phase is the most important phase of the vault.
23	(Requejo, McNitt-Gray, & Flashner, 2004)	3 elite gymnasts	Multi-variant dynamic model experimentally validated.	Kinematic shoulder	The modification torque shoulder during the flight phase allows gymnasts maintain lower body kinematics.
24	(Sanchez-Bañuelo, 1992)	Does not have	Qualitative research method.	Analysis sport	Sport methodology
25	(Takei, 2007)	23 gymnasts	Kinematic analysis method 3D camera shot in 16-mm to 100 Hz.	Kinematics of mortal grouped	The landing point and the official horizontal distance from later flight accounted for 86% of the variation in scores of judges.
26	(Uzunov, 2011)	1 item	Qualitative literature review.	Mechanical phase of Yurchenko	Progressions model it based on get good height at the entrance of the sprinboard with a rapid turnover in the round-off and pre-flight plus a high contact angle of attack to the table.
27	(Uzunov, 2010)	16 items	Qualitative description.	Kinematic variables Yurchenko	Key factors performance Yurchenko are: control the horizontal velocity for the obstacle and pre-element, a high angle of the body in contact springboard, angular maximum input to the table, acceleration in the rotation of the mortal more distance landing.

Table 2
Yurchenko Vault Kinetic and Kinematic Variables.

General Objective Performance Speed and elastic energy			
Phases and sub-phases of the TD		**Mechanical purpose**	**Kinematic indicators**
1. 1st flight	1.1 Run	Generate enough speed and stroke control.	• Speed • Distance
	1.2 Round-off	CM keep close to the ground.	• COM trajectory • Trunk rotation relative angle
	1.3 Spingboard Support	Accumulation of elastic energy.	• Springboard deformation percentage • Contact time with the springboard • Horizontal COM displacement • Flight time
2. 2nd flight	2.1 Table Vault Support	Elastic energy in the ignition.	• COM Speed • Shoulder flexion angle relative • Contact time with the table • Percentage deformation of the table
	2.2 Back Flip	Accelerate the rotation.	• Angular acceleration coxofemoral • Bending angle relative coxofemoral • Flight time
	2.3 Landing	Stability center of mass.	• Relationship COM with support base

DISCUSSION

From the Yurchenko since its incorporation into the Code of Points in 1982 has gained great popularity from the gymnastic community, due to its high score value and its high level of difficulty, many authors have shown that the careful study of the Yurchenko phases reveal a wide spectrum of Kinematic Indicators involved in its correct execution (Koh, 2007). Moreover, more studies about Kinematics have not been published in relation to the vaults that show a superior performance.

Through knowledge of the MP, suggests a great mechanical or muscular feature required at each stage of this ST. Due to these mechanical implications, an independent study of each KIm constitutes, in this vault´s type, one of the key factors in minimizing the difficulties of the element and effectively helping in the execution of Yurchenko vault. This is why the criterion about the KIm, which is presented in the Yurchenko vault, such as the position of entry to the exercise, the types of rotations in the longitudinal and antero-posterior axis, in addition to the COM control depending on the speed produced, make this vault an interesting source of study for the researchers in AG.

In 2001 some issues still uncertain about the distance and the measures of the apparatus itself were regularized and identified as: a) distance in focus, from the starting point to springboard, is 25 m included an approach distance from the springboard point. b) a rectangular vault

table with a surface measuring of 120 cm long and 95 cm wide (Boldrini et al., 2016). Hence, is here when the knowledge of the apparatus or devices, for both, the coach and the gymnast, lies in the effectiveness of the teaching of. Within the main kinematic and kinetic characteristics involved in the execution of the element, we have the percentage of deformation and the contact time applied in both, on the springboard and on the vault table applied (Koh, 2007), information that is often ignored by many coaches.

In some studies (Boldrini et al., 2016;Bermejo, 2013). It was noted that existing information between the liaison between AG and kinematics and kinetics is still incipient; this is because only in the recent years researchers have recognized the great influence of the kinematics and kinetics in the proper execution of a specific motor task.

During the development of this review can account for some positively correlated suggestions that add punctuation in this type of vault as: changes in the rhythm and slowdowns of the gymnast to make the transition of the race in the round, The minimum contact time on the springboard, there must be a shoulder flexion angle passed the 180° which is vital for a quick repulsion on the table, all the above added to the acceleration during the rolled movement in the mortal and a precise landing, are the appropriate pedagogical guideline and leads to obtaining an optimal and adequate competitive form of TD (Collazo, 2007).

CONCLUSIONS

The systematic analysis of each phase of the yurchenko jump, highlight the kinematic and kinetic indicators that make possible its correct execution, hence the importance of its inclusion in training sessions designed to acquire this sports technique by the gymnasts. The kinematic and kinetic indicators identified in each of the phases of the Yurchenko vault are:

- Speed
- Run Distance
- Acceleration
- Horizontal Displacement
- Trajectory
- Springboard contact time
- Table contact time
- Flight time
- Springboard deformation percentage
- Table deformation percentage
- Mass center height
- Mass center shifting
- Mass center trajectory
- Relative Angle Trunk rotation
- Relative Angle Shoulder Flexion
- Relative angle bending hip joint
- Mass center-base support

The individualized training in each of the Klm could be the key to give greater efficacy in the execution of ST. Rethinking the teaching oriented towards the OGR seems to be a great challenge in the sporting field, it must have fundamental clarity in the WP of each phase, in order to find the variables that are needed in an efficient session or technical training cycle, This is due to the complexity and variability of ST in gymnastics, it is pertinent to analyze each event separately and it is necessary to analyze the kinematic aspects of the performance, and to determine the variables that could increase the score. It is projected with this article to promote the knowledge in the Klm and KIn in the execution of the elements in AG, in any modality; it is must clarity the correction of the PM to meet assertively with the OPG. The present collection is an emergent edition of the ST analysis, determining the importance of orienting the OPG and its elements appropriately.

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SHORT HISTORICAL NOTES XIV

Anton Gajdoš, Bratislava, Slovakia & Michal Babela, Faculty of Physical Education and Sports, 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.

100 YEARS OF CZECH AND SLOVAKIA GYMNASTICS FEDERATION

Miroslav Tyeš (1832-1884) founder of Sokol movement did not live long enough to be present when Czech Sokol clubs made association in 1887. Ten years later in 1897 Czech Sokol federation joint FIG and started to compete at international level. Already in 1900 at OG in Paris gymnast František Erban from Bohemia (as Czech state did not exist yet, they were under Austro Hungarian imperia) attended competitions. At OG 1908 and under Bohemia name again men attended competition, while since 1907 they attended World Chamionships. After the WWI new Czechoslovakia Sokol Federation started to work, and in 1919 Masaryk župa (association) in Slovakia have been established. Since than Czech and Slovak gymnasts started to compete at all major international competitions. Before the WWII they were top gymnasts and wining gold medal at OG starting with Bedrich Šupčik in Paris 1924. At 1936 OG in Berlin Alois Hudec won gold on rings. However even more impressive are Hudec's athletes abilities, as he was able to climb 7m rope in 10 seconds, run 100m in 12 seconds, 3m in pole vault, shot put with left or right arm 10 m, high jump of 1.6m and long jump of 5.2m, and considering technical conditions are those results to admire. At World Championships Vlasta Dekanova made double crown as won in 1934 and 1938.

After WWII in 1948 communists replaced Sokol movement by name and content and organized Czechoslovakia gymnastics federation. Both men and women were again very succesfull at major competitions. At OG 1948 in London women team won gold, despite, few days before competition Eliška Misakova died of poliemilitis. The greatest name after WWII was Vera Časlavska, who was serial winner at OG and WC.

After OG 1968 up to World Championship in 1979 in Strasbourg (France) last gold medal have been won as Vera Černa was the best on beam. At World Championship in 1983 Hana Rična took silver on beam.

In 1993 Czechoslovakia gymnastics federation split due to political circumstances, and since than Czech and Slovak gymnastics federations compete at FIG or UEG events as separate federations. Gymnasts from both federations have a great gymnastics knowledge, what is caused by excellent coaches, judges and organizers. Despite their results are not similar to pre WWII results, their results are rising, wining World Cup competition, and competing at OG.

On 6th October 2018 both federations prepared in Bratislava excellent show, celebrating gymnastics, with honorable guests Yuri Titov (honorable president of FIG) and George Gulzec (honorable president of UEG). Young gymnasts, rhythmic gymnasts and acrobats showed in gala why gymnastics is basic movement and base for all other sports.

Yuri Titov during his speach

From left: Ivan Čuk, Karol Spacek, George Gulzec, Jozef, Mikula, Pavel Dus

From left: Viliam Kocian, Jiří Urbanek, Gabriel Varga, Jiří Tabák, Gejza Pomšár

Vera Černa

From left: Anton Gajdoš, Hana Marejková-Krausová, Ján Novák, Zděnek Ružička the oldest living olympic gymnast 93 years old

From left: Miriam Hullová-Kurilová Jozef Konečný, MartinaKurilová

It is worth to note, in 2018, dipl. ing. Jozef Mikula (on photo with longtime friend Yuri Titov), one of the most significant Slovak artistic gymnastics judges, celebrated his 80th birthday and 60 years as an active judge and 42 years as an international FIG judge (11x Brevet FIG – 1970 – 2012). He judged more than 200 international championships, among others – Olympic Games in Moscow, 12 World Championships (USA, Australia, Europe), 15 European Championships, Mediterranean Games in Spain, FIG World Cup final in Toronto, European World Cups (more than 15x), etc. In 2003 he became FIG Honorary judge and honorable member of Slovak Gymnastics Federation. And he still judges at national level.

Young talents performing their routines

Slovenski izvlečki / Slovene Abstracts

Nunomura Myrian, Roslyn Kerr, Georgia Cervin, Astrid Schubring, Natalie Barker-Ruchti

PRAVILNIK ZA OCENJEVANJE IN RAZVOJ TEKMOVALNE POTI ORODNIH TELOVADK

Predpostavka članka je, da pravila ocenjevanja sestav orodnih telovadk, kot so opisana v Pravilniku za ocenjevanje, pomembno pozitivno in negativno vplivajo na izkušnje starejših telovadk. Cilj te raziskave je bil ugotoviti zaznavanje telovadk, vaditeljev in sodnikov o pravilih in telesnih vzorih, starosti in trajanju tekmovalne poti v Braziliji. S pomočjo kakovostnih pogovorov z dvema vaditeljema in sedmimi telovadkami iz brazilske vrste in štirimi sodniki z mednarodnimi izkušnjami. Vaditelji in telovadke so menili, da so mlajša telesa bolj odzivna na zahteve pravilnika glede zahtevnosti in zahtev pri vadbi. Po drugi strani pa so starejše telovadke imele prednost, ker so bile sposobne nastopati bolj umetniško in z manj napakami. Rezultati bodo omogočili, da britanska in brazilska telovadna zveza razmislijo o tem, kako zahteve pravilnika za ocenjevanje vplivajo na izkušnje telovadk. Ker članek ugotavlja, da pravila in uveljavljena kultura vplivajo na telovadke, je treba upoštevati obe, da bi zdrave telovadke v športu ostale dalj časa.

Ključne besede: telesni ideali, razvoj, staranje, pravila.

Bortoleto Marco, Thomas Heinen, Sun Jun, Eliana Toledo, Laurita Schiavon, Lívia Pasqua, Mauricio Oliveira, Fernanda Menegaldo

KAJ SPODBUJA LJUDI, DA SODELUJEJO NA NETEKMOVALNIH PRIREDITVAH – PRIMER SVETOVNE GIMNAESTRADE

Sodelovanje v športu ima lahko zelo različne cilje, zlasti za ne tekmovalne dogodke. Ta raziskava razčlenjuje spodbude in nagibe udeležencev, da se pridružijo XV. svetovni gimnaestradi v Helsinkih v letu 2015, ki velja za enega največjih mednarodnih ne tekmovalnih telovadnih prireditev na svetu. Vprašalnik ciljne vsebine za spodbude (GCEQ) je bil uporabljen pri 86 odraslih (56 žensk / 30 moških) in izračunani so bili rezultati. Poleg tega je bilo izvedenih 24 kratkih pogovorov in podatki so bili razčlenjeni po vsebini. Socialna pripadnost in razvoj spretnosti sta bili glavni spodbudi. Oba sta za ženske pomembnejša kot za moške. Socialno priznavanje je bilo za udeležence še posebej pomembno. Nazadnje, število udeležencev na dogodku, kaže enako nagnjenost k spodbudi za začetnike in zelo izkušene.

Ključne besede: telovadba za vse, prireditve, spodbude, ne tekmovalna dejavnost, udeleženci.

Paula Debien, Bernardo Miloski, Thiago Timoteo, Camila Ferezin, Maurício Bara Filho

TEDENSKE ZNAČILNOSTI OBREMENITVE IN OBNOVA PRI VRHUNSKIH RITMIČARKAH

Cilj raziskave je bil razčleniti tedenske značilnosti vadbe (ITL) in obnove vrhunskih ritmičark med tekmovalnem obdobju. Sodelovalo je osem vrhunskih brazilskih ritmičark. Ocena zaznanega napora (RPE) in skupne ocene obnove (TQR) je bila zbrana vsak dan v 37-tedenskem obdobju. Podatki RPE so bili zbrani po vsaki vadbi in TQR pred prvo vadbo v dnevu. Za ponazoritev je bila izbrana vsota ITL vsake dnevne vadbe (dITL) in tedna (wITL), kot tudi povprečne vrednosti TQR. Zabeležene so bile tudi smo tudi enoličnosti vadbe in odstopanje. Za razčlenitev je bilo celotno obdobje razdeljena na pripravljalno, tekmovalno in obdobje, ki obsega tedne tekmovanja, v tekmovalnem obdobju. ITL in TQR sta se razlikovala med dnevoma obdobij in tedni tekmovanja. Tekmovalno obdobje kot celota je pokazalo višjo povprečje WITL, dITL in težave ter nižjo enoličnost kot druga obdobja. Toda med tekmovalnimi tedni so imele ritmičarke najslabši rezultat in najvišje ocene enoličnosti, kljub najnižjim srednji vrednostim dITL. Negativna povezanost je bila ugotovljena med dITL in TQR naslednjega dne ($r = -0,333$; $p < 0,001$). ITL in TQR sta se spremenila med obdobji in tedni tekmovanja. Oblika obremenitve v tekmovalnem obdobju in tednih tekmovanja ni zagotovila dobrega okrevanja, zlasti ob koncu tedna. Predlaga se večja spremenljivost velikosti obremenitve, ki lahko vključuje tudi prost dan, med tekmovalnimi obdobji in tedni tekmovanja.

Ključne besede: ocena zaznanega napora, čas obnove, tekmovalnost, ritmičarke.

Amanda Batista, Rui Garganta, Lurdes Ávila-Carvalho

TEŽAVNOSTI S TELESOM V SESTAVAH RITMIČARK

Cilji raziskave so bili: (1) razčleniti raznolikost in raznolikost telesnih težavnosti v posameznih sestavah vrhunskih ritmičark, ki so tekmovali na svetovnem pokalu v Lizboni leta 2013 in 2014; (2) primerjati te značilnosti v različnih razvrstitvenih skupinah; (3) ugotoviti in določiti vrstni red spremenljivk, ki najbolj prispevajo k uspehu pri oceni težavnosti na tekmovanju. Razčlenjenih je bilo 288 sestav, v skladu s Pravilnikom za ocenjevanje 2013–2016. Ritmičarke so bile razdeljene v tri skupine glede na njihovo uvrstitev. Za statistične postopke so bili uporabljeni neparametrična testa Kruskal-Wallisa in Mann-Whitney, Pearsonova korelacija in večkratna regresija. Med vsemi težavnostmi s telesi so bile prvine z vrtenji najrazličnejše, medtem ko so imele prvine skokov najmanj različnosti. Ritmičarke se nagibajo k uporabi enakih skokov, ravnotežnih prvin in vrtenj v vseh svojih sestavah. Ritmičarke v finalu (finalistke) so predstavili večje število sestavljenih prvin (mešanih in večkratnih težavnosti) kot druge skupine. Vendar pa so najboljše ritmičarke pokazale manjšo raznolikost pri izbiri težavnosti s telesnom. Njihove sestave so bile osredotočene na prvine vrtenja in število obratov. Preverjali smo manjše pojavljanje prvin ravnotežja in skokov. Opredelili smo naslednji vrstni red pomembnosti spremenljivk, ki prispevajo k uspehu pri oceni težavnosti: vrednost vrtenja; vrednost skokov; vrednost ravnotežja in vrednost mešanih težavnosti. Zato so vrtenja v sestavah v olimpijskem ciklu 2013–2016 predstavljala večji pomen.

Ključne besede: težavnosti s telesom, ritmika, sestave, vrhunske ritmičarke.

Petr Kutac, Sona Jurkova, Roman Farana

TELESNE ZNAČILNOSTI MLADIH ORODNIH TELOVADK NA ČEŠKEM

Namen raziskave je bil ugotoviti telesne značilnosti orodnih telovadk in jih primerjati z običajnimi dekleti iste starosti. V študijo je bilo vključenih 16 telovadk v posamezni starostni kategoriji in 652 običajnih deklet iste starostne skupine. Telesna višina je bila izmerjena z napravo InBody BSM 370, telesno maso in sestavo telesa z napravo BIA InBody 770 (Biospace, Južna Koreja). Spremljane vrednosti vsake telovadke smo primerjali s povprečnimi vrednostmi nadzorne skupine v ustrezni starosti posebej, pri čemer smo uporabili normalizacijsko razmerje (Ni). Rezultati raziskave kažejo, da se telovadke v najmlajši tekmovalni kategoriji že razlikujejo po osnovnih telesnih značilnostih. Od devetega leta dalje imajo telovadke nižjo telesno višino (razen ene osebe) in nižjo telesno maso kot običajna dekleta. Telesna višina in telesna masa sta pod povprečjem ali zelo pod povprečjem pri devetih telovadkah (56,3%). Velik obseg posebne telesne dejavnosti telovadk, vključenih v njihovo vadbo, vpliva na sestavo telesa. Telovadke imajo nižjo telesno maščobo (%) in visceralno maščobo (cm2), njihove vrednosti so pod povprečjem, visoko pod povprečjem in višjo maso skeletnih mišic (%), z vrednostmi nadpovprečne ali visoko nadpovprečne.

Ključne besede: orodna telovadba, mladina, ženske, telesne značilnosti.

Yaiza Taboada-Iglesias, Águeda Gutiérrez-Sánchez, Tania García-Remeseiro, Mercedes Vernetta-Santana

TELESNA RAZMERJA AKROBATOV V RAZLIČNIH TEKMOVALNIH KATEGORIJAH

Akrobatika je telovadna disciplina pri kateri je pomembna vloga akrobata (vrh ali temelj), ki jo imajo akrobati, ki sestavljajo ekipo. Vzpostavitev telesnega modela je odločilen dejavnik napovedovanja tekmovalne uspešnosti. Namen študije je bil vzpostaviti sorazmernostni model, ki temelji na razmerjih sorazmernosti različnih tekmovalnih vlog, in ugotoviti, ali obstajajo razlike med njimi. Študija je vključevala 150 španskih akrobatov obeh spolov, ki tekmujejo na nacionalni in mednarodni ravni. Meritve so bile izvedene po standardih, ki jih je določilo Mednarodno društvo napredne kinantropometrije. Razdelana so bila različni razmerja sorazmernosti vrhnjih in temeljnih akrobatov, pri čemer je bila opravljena primerjava glede na tekmovalne kategorije. Rezultati so pokazali, da med ženskami ni bistvenih razlik ($p < 0,05$) v izbranih spremenljivkah, pri čemer se ugotavljajo podobnosti v njihovi sorazmernosti. V vseh kategorijah imata tako vrhovi kot baze kratke zgornje in spodnje okončine glede na razvrstitev teh razmerij. Srednja dolžina trupa prevladuje v vseh kategorijah, razen moškega para. Večina akrobatov ima valjasto obliko trupa, razen v nekaterih primerih, ko ima trapezoidno obliko (vrhovi v parih žensk in temeljni v moških in mešanih parih). Razlika med razponom in višino roke je upoštevana pri obeh vrhovih in temeljih, glede na njihovo tekmovalno kategorijo. Rezultati kažejo, da je treba upoštevati majhne razlike v telesni sorazmernosti, da bi akrobate usmerili k določeni tekmovalne vloge.

Ključne besede: akrobatika, telesna razmerja, tekmovalna kategorija.

Michalis Proios

VPLIV METODE POUČEVANJA ZAHTEVNE TELOVADNE PRVINE NA VISOKO, SREDNJE IN NIZKO SPRETNE UČENCE

Ta študija je preučila učinek načina poučevanja v poučevanju zahtevne telovadne prvine in primerjala dosežke nizko, sredne in visoko spretnih učencev na uspešnost izvedbe le-te. 46 učencev prvega srednješolskega razreda, starih od 12 do 14 let, dveh razredov, je bilo udeleženih v poskusu, kjer so izvajali stojo na rokah in spojeno preval naprej (12 vadb), po 30 minut, 2-krat na teden. Uspešnost dela je bila zabeležena in ovrednotena pred, po vadbi in dva tedna po koncu poskusa. Na podlagi začetnih sestavljenih izmerjenih rezultatov so bili učenci razvrščeni v tri enake skupine nizke, srednje in visoke spretnosti. Analiza variance 3 x 3 (preskus skupine na ravni spretnosti) s ponovljenimi meritvami v zadnjem dejavniku je pokazala, da so vse skupine izboljšale svoje rezultate tako v rezultatu (količinsko) kot v tehniki (kakovostno) stoje na rokah in spojeno preval naprej in da obstajajo pomembni učinki na raven spretnosti učencev. Ta študija je pokazala, da so se nizko spretni učenci v večji meri izboljšali v primerjavi s tistimi, ki so srednje in visoko usposobljeni.

Ključne besede: metoda poučevanja, učenje gibanja, telovadne spretnosti, mladostniki.

Sameh Wali-Menzli , Sarra Hammoudi-Nassib , Souhaila Ismail, Sabra Riahi Hammoudi, Ines Knani Hamrouni, Mohamed Jarraya

VPLIV MISELNIH PREDSTAV NA IZBOLJŠANJE UČENJA IN IZVAJANJA TELOVADNE PRVINE

Namen raziskave je bil ugotoviti učinek treh vrst predstav ((a) zunanje miselne podobe, (b) besednega načina povratnih podatkov in (c) miselne predstave na preval nazaj v stojo na rokah. 42 študentk (starost 20,6 ± 1,3 leta) je prostovoljno sodelovalo v tej študiji. Študentke so bili razvrščene v tri skupine glede na tri načine učenja: zunanje vidne podobe, besednih povratnih podatkov in duševne predstave. Vsaka študentka je bila v času vadbe (pred in po vadbi) izmerjena v skladu s pravili za ocenjevanje. Rezultati razkrivajo pomemben vpliv na vadbo, torej na učenje prvine po metodi zunanje miselne podobe. Tako se zdi, da je miselna podoba orodje za prenos znanja in usposabljanja, kar omogoča študentkam, da napredujejo, medtem ko se znebijo pomanjkanja motivacije, organizacije, vpliva in dela. Poleg tega rezultati, pridobljeni po vadbi, kažejo tudi na izboljšanje uspešnosti prve skupine, ki je morala opraviti vadbo z besednimi povratnimi podatki. To podpira zamisel, da usposabljanje z metodo besednih povratnih podatkov izboljša tehnično zmogljivost. Vendar se zdi, da je metoda usposabljanja z miselno predstavo manj razvita s strani udeležencev v primerjavi z ostalima dvema metodama.

Ključne besede: čutni povratni podatki, učenje gibanja, akrobatika.

Dallas George, Alexandros Mavvidis, Ioanna Kosmadaki, Sofija Tsoumani, Konstantinos Dallas

SPREMEMBA ZMOŽNOSTI MIŠIC PO DVEH RAZLIČNIH NAČINIH GLOBINSKEGA SKOKA PRI MLADIH ORODNIH TELOVADKAH

Namen raziskave je bil preučiti učinek po-aktivacijskega potenciranja (PAP) dveh različnih dražljajev (CS) na parametre globinskega skoka (DJ) na mlade telovadke. Trideset mladih telovadk, starih od 8 do 13 let, je izvedlo dva načina meritev z dvojnim skrčenim skokom (DTJ: 2 niza po 5 ponovitev) ali blaženjem nog (LBA: 2 niza po 5 ponovitev) v naključnem zaporedju. Pred in takoj po izvedbi PAP-a ter 4, 8, 12 in 16 min po tem, je bila izmerjena skakalno sposobnost z globinskim skokom (DJ). Rezultati so pokazali pomemben medsebojni učinek med dvema CS za višino DJ ($p < 0,002$), trajanje leta ($p < 0,002$) in odrivno hitrost ($p < 0,003$). Poleg tega je bil ugotovljen pomemben glavni učinek za meritev na višini DJ ($p < 0,001$) in trajanje leta ($p < 0,001$). Priporočljivo je, da športni strokovnjaki vključijo podobne dražljaje v postopek ogrevanja, da bi izboljšali svojo zmogljivost skakanja. Končno, tako CS povzroča pojav PAP, vendar posebni CS proizvaja višje stopnje izboljšav pri mladih orodnih telovadkah

Ključne besede: pliometrična vaja, orodna telovadba, globinski skok.

Ligia Diener, Esteban Aedo-Muñoz

KINETIČNI IN KINEMATIČNI KAZALNIKI PRVINE JURČENKO NA PRESKOKU - PREGLED VIROV

Namen tega članka je bil določiti najpomembnejše kinetične in kinematične kazalnike prvine Jurčenko na preskoku. Razčlenjene so bile mehanske značilnosti vsakega dela prvine. Dosledni kvalitativni pregled je bil izveden z začetnim iskanjem 67 znanstvenih dokumentov, od katerih jih je bilo 27 izbranih z ujemanjem ključnih besed Jurčenko, kinetične, kinematične in orodne telovadbe in njihovih kombinacij. Ugotovljeno je bilo, da so glavni kinetični in kinematični kazalniki pri prvini: pospešek, hitrost, razdalja, pot, kontaktni čas, čas poleta, odstotek odstopanj in vrtilna količina, ki deluje na telo. Ta članek je predlagan kot študijski pripomoček za usmerjanje k pravilni smeri kinetičnih in kinematičnih dejavnikov, ki jih je treba upoštevati pri učinkovitem izvajanju tehnike prvine Jurčenko na preskoku.

Ključne besede: Jurčenko, kinetika, kinematika, preskok.

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DEAR FRIENDS, THANK YOU FOR YOUR DILIGENT WORK.

Aleksić- Veljković, Aleksandra
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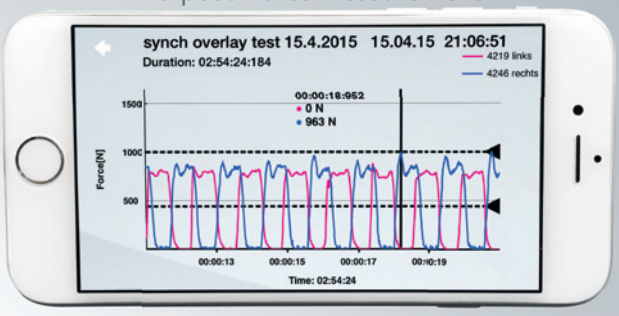

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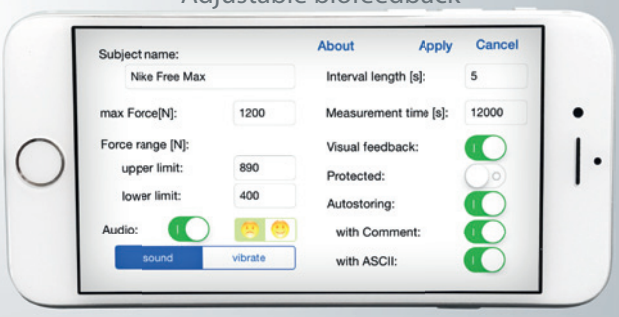

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