

# SCIENCE OF GYMNASTICS JOURNAL

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# Science of Gymnastics Journal (ScGYM®)

Science of Gymnastics Journal (ScGYM®) (abbreviated 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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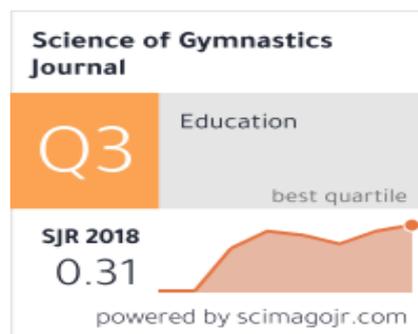
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Authors of the book *Mister Leon Štukelj and Comrades* with Leon Štukelj's daughter. From left: Aleks Leo Ves, Alenka Puhar, Lidija Pauko (daughter of Leon Štukelj) and Ivan Čuk.



Presentation of book at Faculty of Sport, celebrating also 100 years of Ljubljana University, as Leon Štukelj was one of the first graduates (in 1924) and the first Slovene Olympic Champion in year 1924 (both photos by Bogdan Martinčič).

## EDITORIAL

Dear friends,

We have been publishing scientific articles about gymnastics for a dozen of years. 2020 will be marked by the Olympic Games in Tokyo (Japan). We expect excellent gymnastics and perhaps some new records even though gymnastics is normally not about records. We believe that many articles published here in the past have contributed to safer and better gymnastics.

The present issue brings seven articles from different lines of gymnastics, including general gymnastics, rhythmic, artistic gymnastics and acrobatics. Their topics range from sociology, psychology, motor abilities and motor control to physical education.

There authors are from Brazil, Greece, Canada, Germany, Slovenia and Spain.

Anton Gajdoš drafted another article related to the history of gymnastics, refreshing our awareness of Nikolay Adrianov, an excellent Russian gymnast who marked the era between 1970 and 1980 and later as a coach in Russia and Japan.

Special thanks to our reviewers whose diligent work has improved the quality of the published papers. The list of reviewers in 2019 is at the end of this issue.

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

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

Ivan Čuk  
Editor-in-Chief



# GYMNASTICS FOR ALL: DIFFERENT CULTURES, DIFFERENT PERSPECTIVES

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*Original article*

## **Abstract**

*Gymnastics for All (GfA) is a physical activity whose boundaries are not clearly defined from an institutional perspective. Thus, it is necessary to understand the conception adopted in GfA and its value for each social group. This study aims to discuss how different National Governing Bodies (NGB) of Gymnastics approach GfA. We asked 44 NGBs, represented by general administrative and/or GfA-specific members, about the definition of GfA adopted by the countries they represent. We used an online questionnaire hosted on Google Forms®, in four languages. The answers were analyzed through Content Analysis, whose categories were created based on a mixed model. Its strategy adopted an iterative construction of an explanation. Although similar principles of GfA can be found in different definitions, the results of the questionnaire showed that GfA means different things to each social group, so it is difficult to discuss one single understanding. Rather, it is more reasonable to think of GfA as a set of understandings. We understand that the value of GfA resides precisely in this wide variety of meanings and in the life-long practice of Gymnastics.*

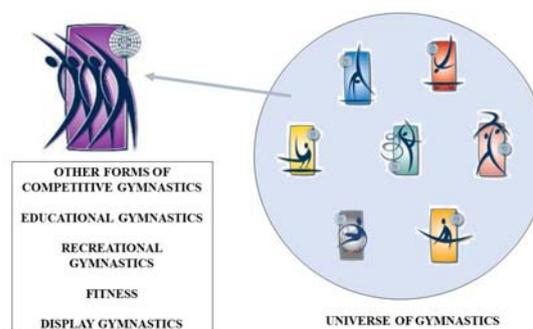
**Keywords:** *Gymnastics for All, approach, national governing bodies of Gymnastics.*

## **INTRODUCTION**

Gymnastics for All (GfA) is a way to practice gymnastics that is shaped by the objectives, interests, and sociocultural aspects of each group or practitioner. Since it is not a discipline with predefined rules or mandatory requirements, GfA can be adapted to different purposes. According to the International Gymnastics Federation (FIG), it involves gymnastics in an educational and recreational context, fitness, and gymnastics performances, as represented by Figure 1. Hartmann (2010) quotes FIG by saying that, according to FIG, “General Gymnastics comprises all gymnastics activities that cannot be called a performance or high-performance sports in international competition.” (p. 25).

In addition to the assumption that it is a gymnastics discipline for people of all

genders, ages, skills, and cultures, it can involve gymnastics and dance activities, with or without apparatus (FIG, 2009). According to FIG (2010), GfA can also be defined by its 4F philosophy: having *fun* since participants who don't have fun will not continue this activity; fostering *fitness*



*Figure 1. GfA according to FIG.*

because participants who are not fit cannot improve their gymnastics skills; teaching good gymnastics *fundamentals* because they are the basis for all gymnastics disciplines; and fostering healthy *friendships* because these environments should encourage good relationships. FIG also highlights the pleasure of being part of and representing a group or association, which expands the reach of GfA in various fields, like clubs, schools, and associations. FIG believes that GfA is the basis of all types of Gymnastics (FIG, 2010).

The fact that it includes several activities like GfA reflects FIG's role in coordinating, organizing and publicizing large festivals that display several possibilities of these activities (Bortoleto, 2008; Russell, 2014). This choice also ensures a significant number of FIG affiliates since it allows the practice of gymnastics as a starting point (the early involvement in gymnastics by children and youth in mass sports), or after the end of an athlete's career (former athletes who want to maintain active involvement in gymnastics in a non-competitive environment, for leisure and health promotion purposes), or even to partake in gymnastics for leisure, keeping it an important influence on the sports life of the largest number of people possible.

Consequently, FIG (2010) indicates that each National Governing Body (NGB) can offer the types of gymnastics and events/programs it wishes to develop or believes to be beneficial to promote the practice of gymnastics in their region. Among the factors that can influence the choices made by NGBs to foster GfA, two are worth mentioning: aspects related to the management of sports organizations, using the same rationale of the importance of GfA to FIG, and the conceptions of Gymnastics, society, leisure, and health adopted by each country or social group.

Regarding administrative factors related to NGBs, it is reasonable to claim that the broader the definition of GfA, the greater the number of affiliates of that

NGB, which can significantly increase the budget of NGBs. They can also keep control of the activities they offer and of how gymnastics coaches, whether voluntary or professional, work and are trained. One example is from the German Gymnastics Federation (DTB), which, according to Hartmann (2010, p. 29), had 5 million members in 2010: 80% of them were enrolled in GfA activities, especially those related to fitness and health promotion.

Despite some institutions invest the budget collected with GfA again in this practice, it seems that, sometimes, the money from the participative Gymnastics ends to finance competitive Gymnastics. So, the maintenance of GfA in many institutions can not have as objective the development of actions that aim the access of people from different profiles to Gymnastics or the educative effort, but providing other forms of Gymnastics that attract more the media, sponsors and international organizations.

Research studies should also address the conceptions adopted by NGBs that determine their understanding of what Gymnastics is and how NGBs relate to society, leisure, and health. These conceptions show how social groups - and consequently national governing bodies - see their own activities and how they develop policies to promote gymnastics. This insight can help us understand GfA in several territories. It also fosters reflection, which is crucial for our local understanding of the importance of collectively discussing and building the guidelines to be adopted by each group or country. Globally, it can help us learn how to interpret GfA according to the culture it stems from.

This paper aims to discuss how different NGBs understand the role of GfA.

## METHODS

This study uses a descriptive, exploratory, qualitative research approach. In January 2016, 138 NGBs affiliated to FIG were invited to participate in the survey. Contact was made based on their contact emails available at the NGB Directory at the FIG website or from contacts previously known to the research team. Out of these, 44 NGBs agreed to answer an online questionnaire hosted on the Google Forms® platform. The questionnaire was provided in Portuguese, English, Spanish, and French. It had open-ended and closed questions about how federations were organized, their understanding of GfA and about information on teacher training programs that they offered. Specifically, this paper will discuss the question related to how the respondent's NGB understands the role of GfA. It was an open-ended question that read: "According to your federation, what is Gymnastics for All?" NGBs were represented by members who work in the administrative office and/or members who work specifically with GfA and with coach training. One answer was removed from the survey results because the respondent did not understand the question.

Answers went through a Content Analysis process, where categories are created from a mixed model. We adopted a

strategy that uses iterative construction for explanations (Laville & Dione, 1999). We analyzed answers using their units of analysis but we were also careful to look at answers as a whole, discussing their overall meanings.

Here are some limitations of the study: a) some of the NGBs invited to participate in the survey do not use the languages provided as their preferred language of communication, which may have influenced the answers we obtained; b) some countries do not allow the use of Google® platforms in their territories. In these cases, even after sending the questions using different communication systems, their governmental agencies did not allow them to answer the questions; and c) it is possible that the answers reflected the approach of a particular NGB, but it may not be the one actually adopted in that country, as it will be discussed in the Closing Remarks section of this paper.

## RESULTS

Table 1 present the full transcripts of the survey answers. This chart provides the answers in English and the footnote brings each answer in the language they were originally answered, in the case of questions answered in Portuguese, Spanish, or French.

Table 1  
*Definitions of GfA according to NGBs – Part 1.*

Country	Answers
Algeria	Gymnastics for all ages, focused on everyone.
Andorra	A sport that combines art, dance, elegance, strength, coordination, and flexibility.
Argentina	The members of my federation have no knowledge on Gymnastics for All. This is why my job, for now, is to spread the activity.
Australia	Gymnastics for All is a sport for everybody. You can develop amazing skills while getting strong and flexible in fun and challenging ways; it is a sport for life with something for all ages and all abilities.
Austria	The Basis of all gymnastics disciplines, very important for all Clubs, for all ages and many levels, competitive and non-competitive.
Azerbaijan	Gymnastics for All was established in Azerbaijan when the national team joined the World Gymnaestrada in Helsinki (Finland) in 2015 for the first time. It is the event where the representatives of all gymnastics disciplines can be united to make a great

	performance with a participation of people of different ages and without competition tension in a friendly atmosphere.
Bangladesh	Gymnastics for is gymnastics for everyone of all age people of the country.
Barbados	Gymnastic movement that is inclusive of all people, ages and abilities.
Benin	Gymnastics for All according to our Federation is the type of Gymnastics that everyone can practice without distinction of sex, age, race, or religious affiliation. This type of Gymnastics allows you to practice sports while having fun and improving your health.
Brazil	My NGB sees it as synonym of the World Gymnaestrada. I emphasize that I've been struggling to change that.
Canada	Gymnastics for All is gymnastics for all ages, all levels, and all abilities.
Cayman Islands	We do not have GfA program in Cayman.
Cape Verde	A discipline of gymnastics that includes all genders and age groups.
Denmark	Gymnastics for all is gymnastics without competition (VM, EM ect.).
Estonia	Moving together in fun atmosphere.
Finland	Gymnastics for All is a broad family of different kind of gymnastics styles. Focus in GfA is more on fitness, health, experiences and performing than competing. We do have some competitions under these styles, but that isn't the main focus, purpose or aim of the activity. GfA isn't age limited; we have activities for all age groups.
Great Britain	More opportunities for more people to take part in gymnastics.
Germany	Movement activities (in the field of dance, sports, recreational sports, lifestyle movement activities etc.) with no competition or competition on a low level that include various offers for all age groups and genders. Often the offers belong to health-orientated sports.
Hong Kong	Suit for everyone.
Ireland	Participation-based Gymnastics. Inclusive Gymnastics. Display Gymnastics.
Iceland	All gymnastics discipline that are under FIG and UEG are GFA. The basic gymnastics and performances.
Italy	The Gymnastics for All is a range of activities in which ALL (adults, children, over..., disabled, amateurs, athletes...) can find a type of work suited to them.
South Korea	Gym for all for general people's health.
Kosovo	A sport for everybody, regardless of age, gender. It is the perfect activity to prepare children for long-term participation in sport and develops vital life skills. Additionally, is one of the eight gymnastics sport disciplines officially recognized by The International Gymnastics Federation and gymnastics organizations worldwide.
Libya	It is the collective activities of any age by the sports movements, either alone or in the performance of mathematical tools, and done without code of points.
Luxemburg	We currently include General Gymnastics and recreational gymnastics in all its forms.
Monaco	Gymnastics practiced by a population of all ages.
Mozambique	Modality directed and accessible for all.
Mauritius	The foundation of any gymnastics/physical activity; the mother of all sports, practiced by people of all age groups.
Namibia	The opportunity for everybody to join gymnastics, irrelevant of talent.
Norway	All activities for children, youth, adults, elderly, without competition.
Paraguay	It is a gymnastic modality of non-competitive basis that fosters the health and participation of everyone who is attracted to physical activity and that is part of a group, who performs in creative and particular forms of expression.
Portugal	Gymnastics for All offers a wide variety of activities suitable for all genders, age groups, with different technical skills and cultural backgrounds. It is recognized that GfA activities contribute to personal health and physical, social, intellectual and psychological well-being. The great goals of GfA activities event are fun,

	friendship, physical fitness, and fundamentals of gymnastics. GfA performances can involve: Gymnastics with or without apparatus and Gymnastics and Dance. For the International Gymnastics Federation, Gymnastics for All is considered the basis of all gymnastics disciplines, physical activity and sports in general.
Qatar	The practice of GYMNASTICS by everyone, different ages and genders. Preparing a show with our gymnasts from different disciplines.
South Africa	Foundational gymnastics; mass participation; display gymnastics.
Singapore	Gymnastics for Everyone - a non-competitive FIG Discipline.
Slovakia	Basic part for development of our federation and gymnasts.
Sweden	All gymnastics without elements of competition based upon technical regulations (i.e. there might be elements of competition/challenges but it is not the main objective for training).
Trinidad and Tobago	Gymnastics for Gymnasts who do not train or wish to compete at the higher levels or who have competed and come back to gymnastics for pleasure. For all ages and physical abilities.
United States	We have non-competitive, competitive and special needs components.
Venezuela	Modality of gymnastics aimed at the participation of all age groups, whose main objective is to conduct healthy, recreational, creative, non-competitive physical activities.
Gran Canaria	Gymnastics practiced by anyone who does not want competition.
Aruba	Gymnastics for all ages and all levels.

Based on the Content Analysis of the answers obtained, the most recurring and the most significant aspects of definitions were identified (Tables 2).

Table 2  
*Content Analysis of GfA approaches.*

Theme	Units of analysis (number of hits)	%
Possible types/groups of participants	Accessible to everyone (6); all genders and age groups, with various levels of technical skills and cultural backgrounds (1); all genders and age groups (4); all age groups (8); everyone who does not want to compete (1); everyone who feels attracted to physical activity (1); mass participation (1); sports for all (1); all ages and skills (6); possibilities for people with special needs (1); anyone, regardless of talent (1); for more people (1); for those who are not high-performance gymnasts or who do not want to participate in high-performance competitions or those who once competed and wish to partake in gymnastics again for pleasure (1).	72.7%
Relationship with competition and participation	Non-competitive aspect (6); promotion of some competitions, although this is not the main focus, purpose or goal of the activity (1); competitive and non-competitive (2); with no competition or with low-level competition (1); All-inclusive gymnastics (1); Recreational gymnastics (1); Performed without a scoring system (1).	34%
Activity type	Modality (3); discipline (1); gymnastics expression (3); sports (1); fundamental gymnastics; fundamentals of any gymnastics/physical activity (1); mother of all sports (1); sport for life (1), large family of various gymnastics styles (1); variety of activities (1); sports (1); movement activity (in the field of dance, sports, recreational sports (1); physical activities related to life styles, sports focused on health promotion (1); more opportunities to participate in gymnastics activities (1); every gymnastics without competitive elements based on technical rules (1); Inclusive gymnastics (1).	31.8%

Goals of GfA	Fun, friendship, fitness, fundamental gymnastics (1); performing healthy, recreational, and creative physical activities (1); fitness, health, experiences, and performances (1); overall health (1).	15.9%
How GfA is practiced	Gymnastics with or without apparatus and Gymnastics and Dance (1); performance gymnastics (4); show (1).	13.6%
Role of GfA in Gymnastics	Basis of all gymnastics disciplines, of physical activity and of sports activities in general (2); Fundamental gymnastics (1).	11.3%
Administrative issues	Important to all groups (1); basic aspect for the development of our NGB (1); FIG discipline (1); one of the eight disciplines recognized by FIG and other Gymnastics organizations all over the world (1); all disciplines that are controlled by FIG and UEG are GfA (1).	11.3%
Benefits of GfA	Personal health and physical, social, intellectual, and psychological well-being (1); health (1); development of amazing skills (1); strength and flexibility (1); preparing children for long-term sports practice (1); development of skills for life (1); fun and health (1).	6.8%
General characteristics	Combines art, performance, elegance, strength, coordination, and flexibility (1); joy and a challenging environment (1); fun atmosphere (2); Gymnastics of different disciplines.	6.8%
Association with events	World Gymnaestrada (2).	4.5%
Number of participants	Arranged in groups (2); collective activities (1); both individual and group activities (1); representatives of all gymnastics disciplines can be gathered (1).	4.5%
Teaching methods	Guided (1).	2.2%
Others	There is no knowledge on GfA at the NGB (1); GfA programs are not developed at the NGB (1); did not understand the question (1).	6.8%
Legend: %: Percentage of countries that mentioned the theme		

## DISCUSSION

It is interesting to see that the key feature of GfA that was listed in the definitions (mentioned by 72.7% of participants) is the wide range of categories of participants. According to the answers, it is boundary-free and all-inclusive. It is worth mentioning that there was a high number of answers saying that GfA is an activity for all age groups (8), accessible to everyone (6) and for all age groups and skills (6).

This characteristic feature raised by the respondents places GfA in opposition to competitive Gymnastics disciplines, since GfA is seen as a discipline that stands apart from other gymnastics disciplines. We can say that NGBs see GfA as an activity for all types of people and that they believe that competitive disciplines are not for everyone but rather for participants with specific features -

skilled participants who seek to achieve technical perfection and beat their competitors. This is confirmed by one of the answers, which states that GfA is a practice “for gymnasts who do not train or wish to compete at the higher levels or who have competed and wish to go back to gymnastics for pleasure.” This argument shows that, historically, Gymnastics aims to improve fitness, as already noted by Langlade and Langlade (1970) and Soares (2012).

According to this perspective, GfA can be seen as part of all gymnastics disciplines: GfA is present in sports initiation activities in Artistic Gymnastics, in adaptive Rhythmic Gymnastics at the Special Olympics, in beginners’ groups in Aerobics, as well as in large group performances, fitness practitioners, among other types, as it is recognized by FIG. We notice that this approach is adopted by some NGBs (like Mauritius and South

Africa), which see GfA as a way to partake in Gymnastics, while other NGBs see GfA as an activity with an independent identity (for example, Singapore and Venezuela).

Nevertheless, we would like to highlight that some NGBs have put themselves at risk by determining that competitive gymnastics disciplines are only for high-performing athletes and for a specific audience. Thus, they have rejected the idea that, regardless of the discipline, sports can, among other roles, work as a facilitator in the pursuit for quality of life for all citizens (Paes & Balbino, 2009). Concurrently, ordinary people are not given the opportunity to participate in competitions, which can lead to experiences, feelings, discoveries, and repercussions in one's life that will stem from risk, adventure, challenge, and demands often found in a competitive environment (Bento, 1999). It is important that, at the same time, managers of gymnastics disciplines dedicate some time to reflect on competition models adopted and enhance them, so that these activities can be offered to everyone and not only to talented athletes. Coaches and managers should have a more educational focus on the organization of gymnast training programs, so that the 4Fs - stated by FIG (2009) as the focus of GfA - could be part of all gymnastics disciplines and not only of GfA.

Another observation to be made is related to the fact that despite being considered to all the genders, as other gymnastics disciplines, GfA is predominantly practiced by women (Silva & Barata, 2016; Silva, Santos-Rocha, Barata, & Saavedra, 2017; Soares, Bortoleto, Ayoub, Paoliello, & Carbinatto, 2015). This information, opposed to the conceptions of GfA of the big part of the NGBs, is important to inform the policies of promotion of this practice that should be encouraged by the national and international institutions to stimulate the increase the number of practitioners.

The second most common category (34%) was the "relationship with competition and participation". Countries stressed the non-competitive aspect of GfA (6), the fact that it can be competitive or non-competitive (2) and that it involves all-inclusive gymnastics (2). The wide range of answers regarding GfA and even the various ways to practice it, as indicated by FIG itself allow GfA to be considered *essentially intended for performance*, but not *exclusively so*.

Gym for Life Challenge is an event that can be described as "a type of worldwide championship for amateur Gymnastics clubs" and "another stage for GfA to showcase skills in a friendly environment" (FIG, 2017, p.1) and it has been promoted by FIG and rolled out by many NGBs. FIG considers this event "an international contest for Gymnastics groups" (2011, p. 6). The promotion of this event validates the answers that state that GfA is non-competitive as well as those that describe it as all-inclusive or hybrid, since its non-conventional format allows other similarities with an all-inclusive activity. Other studies about this event are being carried out and soon they will shed more light on this aspect.

Categories "type of activity" - a category that combined the units of analysis related to the nature of GfA - and "How GfA is practiced" - which represents the way GfA is expressed - were the third and fifth most cited categories, with 31.8% and 13.6% recurrence, respectively. The answers indicated different types of GfA activities focused on "performance", which surpassed any other definition of GfA.

This trend is also observed in the definition proposed by FIG. An example of this contrast is a comparison of the definitions of gymnastics disciplines provided by FIG. For FIG (FIG, 2015), Artistic Gymnastics (AG) is defined as "Competitive Gymnastics performed on different pieces of apparatus"; Rhythmic Gymnastics (RG) is "Competitive Gymnastics performed using different

hand apparatus”; but GfA is “Gymnastics without or with competitions (World Gymnaestrada without competition) of a recreational nature covering a wide range of gymnastic activities”. These definitions are similar to those found in the answers provided the NGBs that took the survey. NGBs see GfA as a way to practice gymnastics.

Again, it can be observed that, for some NGBs, GfA does not have its own identity. It is seen as an element of the development stages of other gymnastics disciplines. Another point that stands out is the fact that GfA is considered by NGBs and even by FIG as a discipline that “can be” and not as a discipline that “is”, confirming its adaptative character. About that, Hartmann (2010) says: “It is much easier to define what General Gymnastics does not mean than to describe what it actually is” (p. 25).

It can be observed that the conception adopted for GfA in each country becomes obvious in the definition of this activity and, therefore, of the policies that incentivize and promote GfA. As an example of this analysis, we would like to stress some definitions that were described in the answers: South Korea considers GfA as “Gym for all for general people’s health”; Great Britain, “more opportunities for more people to take part in gymnastics”; Ireland, “Participation-based Gymnastics. Inclusive gymnastics. Display gymnastics”; and the United States claim it is an activity with “non-competitive, competitive and special needs components”.

Therefore, it is possible to infer that, in some countries, policies that incentivize GfA may have an appeal with a stronger focus on health promotion, development of activities that can even be personal and with a purpose other than performing choreographies, like in events promoted by FIG. At the same time, these policies can aim to include as many people as possible and thus be shaped as competitions, contests, festivals, and even

other outcomes that are not related to group performances. The category of analysis “goals of GfA” ranked fourth in the number of hits and it was mentioned by 15.9% of NGBs. It is directly related to this discussion, similarly to the following answers: conducting healthy, recreational and creative physical activities (1), fitness, health, experiences and performances (1) and overall health (1).

Concurrently, other answers show that GfA is seen as one of FIG disciplines and, therefore, NGBs can develop GfA activities. Similarly, “benefits of GfA” (indicated by 6.8% of NGBs) are presented by NGBs in their definition of GfA. This is also a peculiar aspect: what other sport includes the possible benefits of GfA in their description? This reinforces the perception that GfA is an activity that, despite being boundary-free, has characteristics that make it a very specific activity. This is why NGBs indicate different categories to classify GfA, which range from “discipline” or “gymnastics expression” to even “fundamental gymnastics” or “large family of different Gymnastics styles”.

Finally, another relevant point indicated by the data collected is the number of answers that associate GfA with events (unit of analysis “association with events” accounted for 4.5% of the answers). These answers mentioned the World Gymnaestrada, an event promoted by FIG. They show that the policies of some NGBs are exclusively related to the management and organization of national delegations to attend the World Gymnaestrada, and are not necessarily concerned with the development of GfA in their country. Similarly, analysis categories “role of GfA in Gymnastics” and “administrative issues” (both mentioned by 11.3% of NGBs) include answers that describe GfA as the basis for the development of the NGB. If the GfA program is well run, this can represent a large number of affiliates, practitioners and, consequently, users of programs and

events promoted by that NGB. This chart shows weaknesses in NGB management in those cases. Since GfA is characterized as a versatile discipline, as indicated by NGBs themselves and by FIG, the development of GfA has a significant potential to make NGBs more influential.

Aligned with this analysis, Hartmann (2010) states that:

*Today GG (General Gymnastics) has become recognized as one of FIG's varied disciplines. But it was a strong process and the position of GG/GfA (General Gymnastics/Gymnastics for All) inside FIG policy as well in most national gymnastic federations' policy is not as high as it should be for a prospective development of gymnastics at all. (Hartmann, 2010, p. 25).*

That is, there is room for growth for GfA in different countries and worldwide, as long as GfA is discussed, understood and finally developed by managers, coaches, gymnasts and the society in general. Therefore, it is crucial to effectively understand GfA and how this activity can be adapted to needs of a group. This is only possible through the implementation of steps like raising the awareness about the importance of GfA for the development of gymnastics in the countries, adopting a conception, that is, a theoretical-practical perspective that drives the practice of gymnastics, providing technical and pedagogical training to the stakeholders, and promoting events that incentivize and feedback GfA.

In summary, we observed four groups of countries based on how they approach GfA. The first group has the largest number of respondents (n=26); they presented a general approach to GfA. These countries stressed the inclusive and boundary-free characteristics of GfA, in an approach that is similar to the one used by FIG, which shows the influence of this organization in the definition of this physical activity in several countries. Although they give room to diverse GfA outcomes, their definitions specifically mention the possible types of participants,

goals of this activity and its benefits. These are NGBs from various geographical locations and levels of gymnastics.

The second group, composed of Argentina, Azerbaijan, Brazil and the Cayman Islands, provided answers that indicate that GfA is not fully understood or discussed in unison in those countries today. Azerbaijan is a country that has achieved significant results in Rhythmic Gymnastics worldwide; Brazil has achieved good results in Rhythmic Gymnastics in the Americas and has talents with global reach in Artistic Gymnastics but it does not have the same tradition in Gymnastics as Argentina or the Cayman Islands. Therefore, it is possible to conclude that the development of GfA does not match the development level of other gymnastics disciplines, and this is not restricted to one territory. Moreover, note that the respondents of these countries, especially Brazil and Argentina, are aware that GfA is not widely discussed and they are willing to further develop it, which is a positive aspect. The fact that only these countries briefly mentioned GfA does not indicate that it has not quite developed only in these countries - but it shows that these countries are aware of this gap.

South Korea is the only country of the third group since it has a very specific understanding of GfA, focused exclusively on health promotion. South Korea is widely known for its concern with the overall health and quality of life of its citizens. While the average life expectancy in South Korea is 80 for men and 86 for women, in the United States it is 76 for men and 81 for women; in Brazil, 71 and 79 for men and women, respectively, and in Germany, 79 for men and 83 for women, according to the World Health Organization (2018). Therefore, as mentioned before, it is possible to say that the GfA approach adopted by a country is related to the conception adopted by a

given social group and it is not detached from its social context.

The fourth and last group, composed of Austria, Denmark, Great Britain, Germany, Ireland, Iceland, Mauritius, South Africa, Slovakia, and the United States, shows a more utilitarian and administrative understanding of GfA. Overall, these countries see GfA as a physical activity that serves as a basis for other gymnastics. They see it as an organizational part of NGB and as an opportunity to have more people involved in Gymnastics activities. Therefore, although GfA is seen an activity with few unique features, it is instrumental for the development of NGBs. It is interesting to see that most countries in this group have traditionally involved in gymnastics and/or are developed countries with well-structured NGBs, where the sports practice is part of the country's routine. Consequently, it is possible to say that, in these countries, GfA does not necessarily have an identity, but it is characterized as the practice of Gymnastics in general.

Finally, it can be claimed that, regardless of the common political, socioeconomical, or event geographical context where GfA activities are developed, there is no common, shared definition of GfA.

In summary, the analysis of the results of this research study reinforces the hybrid, versatile, and adaptative character of GfA in various NGBs. This is a positive feature if we consider that different NGBs can match the interests of their potential participants to a given GfA format, thus allowing Gymnastics to continue to be developed according to the adopted conception. But the very same feature can have a downside. Given that different countries do not share a common understanding of GfA, establishing global discussions about GfA can be difficult since it can mean different things to different countries and, therefore, theoretical differences will be observed both between researchers and managers.

Globally, FIG puts itself in a neutral position in the way it promotes GfA. This is observed in the events promoted by FIG: they respect different approaches and even different definitions, as mentioned before. Regarding coach training by NGBs, however, FIG and NGBs do not share a common understanding or even among NGBs, which makes the proposal wide-ranging but sometimes superficial. This topic is currently being debated in academic circles and future studies may shed light on other aspects related to it.

## CONCLUSION

The collected data show that GfA, despite having some principles that *may* be present in different definitions, has very specific meanings to each social group. It is difficult to talk about one *single* understanding; it is more reasonable to say there are *understandings of GfA*. In our view, the value of GfA lies precisely in this wide range of meanings, since GfA is the lifelong practice of gymnastics (Schiavon, Toledo, & Ayoub, 2017) which can be adapted to its practitioners and not the other way around. Therefore, "the pursuit of an understanding is nothing more than an attempt to better comprehend, define and express the symbolism of this activity" (Toledo & Schiavon, 2008, p. 221) and, thus, it is necessary to discuss the meaning of GfA for each social group. At the same time, we need to be constantly aware that "there is a historic and unique being behind each understanding and that these understandings were developed in different sociocultural contexts, which also contribute to their specific features" (Toledo & Schiavon, 2008, p. 224), that is, no approach is established by chance: they are part of a political project of a social group where practitioners and managers are not neutral.

Overall, as indicated by Fiorin-Fuglsang and Paoliello (2008), it can be claimed that GfA is currently “a rescue of the Gymnastics of the past, when people still did it for pleasure, for joy, without being concerned with setting records or with a perfect performance” (p. 100), although the desire to compete, even at a lower level or in other formats, is part of some GfA approaches. Consequently, GfA has become a set of exercises with various degrees of specificity of gymnastics disciplines, which get closer to the core of Gymnastics or the elements it is composed of; its major differential, however, is the combination of these elements with the specific features of groups in each territory and its goals or of the “product” it proposes to deliver, whether it is a choreography, a weekly activity or a sequence of exercises to improve the participants’ health.

We stress that, in the understanding of GfA adopted by the group that the researchers of this study are part of and by most Brazilian groups, GfA is not detached from a “process”, because it is inherent to it. Such “process” is educational and has the same level of importance as the “product” of GfA: during its pedagogical journey, the skills and cultural content of practitioners are appreciated and shared among the group members, in a proposal that aims at human development and training (Maturana & Rezepka, 1995) in Gymnastics for participants (Oliveira, Silva, & Silva, 2018; Paoliello, Toledo, Ayoub, Bortoleto, & Graner, 2014; Pérez Gallardo & Souza, 1995; Pérez Gallardo, 2008; Souza, 1997). This approach was developed and studied in Brazil by the Gymnastics Research Group of the School of Physical Education of the State University of Campinas (GPG-FEF-Unicamp), which has been studying this field since 1993 with a groundbreaking scientific production and the organization of academic events in this field. The Gymnastics Research Group is nationally and internationally recognized for its

excellence and it is very influential in the field. Its members have also been involved in teacher training activities across the country. The definition of GfA used by this group is:

An expression of body language that combines various interpretations of Gymnastics (Natural, Standardized, Artistic, Rhythmic, Aerobics, etc) and blends them with other forms of body expression (Dance, Folklore, Games, Theatre, Mimicry, etc.), in a free and creative way, according to the characteristics of each social group, promoting social interaction among its participants. (Pérez Gallardo & Souza, 1995, p. 33).

Although discussions on GfA in Brazil are advanced and despite our continuous effort to keep them, they have not yet reached the Brazilian Gymnastics Confederation. Consequently, they are not represented in the approach presented in the results of this survey. This mismatch between the approaches taken by the management organizations in Gymnastics and practitioners in general can be observed in other countries too. This is a limitation of this study, because the managers’ perspective or their understanding cannot faithfully portray the situation of GfA in the country, both because these managers represent an institution (and therefore do not express their personal opinions or what they perceive as a reality in the country) and because their statements are political positions that often times express what they would like to happen, but not what actually happens.

Finally, we would like to note that all GfA approaches described in the results of this survey show *potential* development of GfA: they involve perspectives of growth and development of GfA for the upcoming years, as indicated by the efforts of managers to promote GfA; proposals to promote the health of practitioners; and focus on continuously providing the opportunity to partake in GfA to leverage

the participation of everyone interested in it, according to their technical skills and cultural interests. The results also show that GfA cannot be treated as a standard global phenomenon. They indicate that we need to focus our attention on academic research and leverage the importance of national GfA events, which can be specifically targeted to meet the interests of each country.

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# THE ROLE OF TIME AND EXPERIENCE TO THE GYMNASTICS FOR ALL PRACTICE: BUILDING A SENSE OF COLLECTIVITY

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*Special article*

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## **Abstract**

*This essay aims to discuss the role of two sociological categories, time and experience, in a particular context of a non-competitive gymnastics practice (Gymnastics for All - GfA). Understanding GfA as a group activity, the collective participation becomes a key element to allow the participants to share experiences in an extended time. This collective experience in GfA seems to be directly related to development and maintenance of social relations and promotion of the sense of belonging, which reinforce GfA as a body practice that defies the performance and the individualization logic that is overly experienced in the contemporary society.*

**Keywords:** *non-competitive sports, sense of belonging, process, sociology.*

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## **INTRODUCTION**

The benefits of regular physical activity for health and social well-being are indisputable and have been exhaustively confirmed by science (Booth, Roberts & Laye 2012; Fletcher, Blair, Blumenthal, Caspersen & Chaitman, 1992; Hallal, Andersen, Bull, Gutholld, Haskell & Ekelund, 2012; Kodama et al., 2009; Lee, Shiroma, Lobelo, Puska, Blair & Katzmarzyk, 2012). In addition, several studies show that long-term adherence of participants in sports and physical activities (PA) programs is crucial, even more important than pursuing, encouraging or starting the participation (Aily, Carnaz, Farche & Takahashi, 2017; Malina, 2001; Room et al., 2017; Schutzer & Graves, 2004; Wankel, 1993).

The long-term adherence to sports and PA programs has been extensively addressed, especially in researches related to motivation (Dacey, Baltzell & Zaichkowsky, 2008; Dishman, 1991;

Kilpatrick, Hebert & Jacobsen., 2002; Ryan, Frederick, Lepes, Noel & Sheldon, 1997). In fact, physiological, psychological and social benefits, including improvements in the quality of life, are often “promised” by sports and PA programs, but they are conditioned to regular and long-term participation. In this sense, motivation is crucial to have a consistent participation and, consequently, to development of healthier habits and behaviors (Frederick, Morrison, & Manning, 1996).

A long-term participation is the base to the competitive sports, and it needs to be associated with motivation regardless of the performance level achieved (Durand-Bush & Salmela, 2002). For that reason, participation in sports programs is mainly studied in the competitive context, giving special attention to the high-level athletes. However, pleasure and long-term participation also lies on the base of

“Sports for All” (Hartmann-Tews, 2002) but only few studies address these questions.

In the last three decades, the Sports for All (SfA) movement has been promoting mass participation on PA and sports programs, mainly as a leisure practice (Green, 2006; Vuori, Lankenau & Pratt 2004). Even though competition can be part of SfA, the non-competitive activities represent the most important group of practices to promote a society physically active. In this context, Gymnastics for All (GfA) as a non-competitive gymnastics discipline is able to gather practitioners worldwide, combining different age groups in all levels of practice (FIG, 2018), promoting an active lifestyle (Jürgen, 1985, Wichmann, 2015).

Based on the facts above, this essay aims to discuss the role of two sociological categories for GfA practice: time and experience. And, how these elements can influence the practitioners in long-term adherence and contribute to the emergence of collectivity sense among them.

## WHAT KIND OF GYMNASTICS FOR ALL ARE WE TALKING ABOUT?

Different understandings about GfA were socially constructed since the XIX century showing particular historical and cultural backgrounds about its practice. For some European countries with a long-standing tradition in Gymnastics, GfA is intertwined as a regular PA performed under supervision based on a systematic methodology, which can be practiced by all age groups promoting health and well-being (Bonde, 2006; Bukh, 1962; Wichmann, 2014). Based on Corbin, Courtine & Vigarello (2006), GfA can also be considered a fundamental part of the physical culture in those countries, combining PA traditions with local folk activities (Gajdoš, Provaznikova & Banjak, 2012). However, in many other places worldwide, the non-competitive

gymnastics practice has been recently incorporated into the physical culture. From a sociological perspective, it is important to consider these differences.

In America, for instance, gymnastics practice was mainly based on European references, implemented through the migratory process since the late nineteenth century (Gems, Borish & Pfister, 2015; Hoffman, 2015; Quitzau, 2013), which certainly influenced the consolidation of competitive gymnastics disciplines, while GfA became less important. In Brazil, non-competitive gymnastics was considered only at the end of the 20th century, around the 1980s (Souza, 1997). First in higher education courses of Physical Education and, years later, in schools and sports clubs, it has been developed in many places as a tool for social and educational development, providing an inclusive sport practice and, consequently, more participation in gymnastics (Patrício, 2016).

So that, GfA represents non-competitive gymnastics that gathers everyone to participate. It can be understood as a collective practice where people create gymnastics choreographies to display in events, and for that reason it also can be understood as an expressive practice (Mateu & Bortoleto, 2017). Although GfA is internationally governed by the International Gymnastics Federation (FIG, 2018), it does not have a scoring system (Code of Points) as happen with the competitive gymnastics disciplines. For that reason, GfA practice allows a huge diversity of movements, styles, cultural backgrounds and even greater creative freedom and integration of the cultural and aesthetic elements of each group of participants (Wichmann & Jarvis, 2014). Those characteristics can be seen clearly at the GfA festivals (Patrício, Bortoleto & Carbinatto, 2016).

In general, GfA practice is a group activity (Bortoleto, 2008; FIG, 2018) essentially collaborative as suggested by the theory proposed by Parlebas (2001).

Consequently the relationship among practitioners needs to ensure a positive collaboration, contributing to the development of social skills, and thereby better group performance. From this perspective, it seems reasonable to recognize the relevance of the collective dimension to GfA (Menegaldo, 2018). According to the critical theory of Sennett (2012), we understand that GfA could become an important tool to development of the communication and cooperation among its participants.

Considering this, the adherence in GfA seems to be associated with development of social bonds and, sometimes, with the sense of collectivity. Recently, Bortoleto et al (2019) suggested that the motivation to participate in GfA programs and events are related to the long period of time that people are able to spend together – social affiliation and recognition – and also to the sense of belonging. As a group activity, the opportunity to exchange experiences reinforce the social benefits of GfA (Wichmann, 2015) and in this sense GfA can be more than a PA program since it combines physical and social development. This combination depends on how experiences are built and shared over time in each GfA group.

## THINKING ABOUT TIME AND EXPERIENCE IN GYMNASTICS FOR ALL

Gymnastics for All offers the possibility to have a “life-long” PA participation (FIG, 2018). The long-term experiences go beyond the practical aspects as to learn gymnastics skills or display choreographies, given the possibility of sharing the individual experiences in order to develop the group itself. In this sense, each group needs to find its own way to accomplish it.

The individual experiences can enrich the participation process especially when participants act actively and openly to share these experiences among the

group. The shared experiences become a collective knowledge that reinforces cooperation and social engagement. When GfA groups empower their members showing that active participation is positive, the social relations strengthened. In this sense, the GfA practice goes beyond physical training, learning techniques, or development of group choreography. Over time, the way each group operates can generate a collective identity. In this sense, the more individual experiences<sup>1</sup> are shared; closer the group will be to have a “common language”. This process reinforces the social bonds, group cohesion and improvement of the quality of group performance (Parlebas, 2001).

This may seem obvious, but in many cases, the group – without any intention – ignores these knowledges, sometimes to follow a technique and the logic predetermined by coaches or older members, very typical in the competitive sports context. However, it is crucial to remember: GfA should promote accessibility, inclusion and participation, so its practitioners are not necessarily former gymnasts, but participants with a diverse of experiences.

Thus, GfA tends to boost participants’ sense of belonging and increase their commitment to the group in the long-term, allowing the strengthening of the social relations of the participants (Menegaldo, 2018). In this sense, experiences that can lead to a sense of collectivity in GfA go

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<sup>1</sup> These experiences can be as many different as possible, including skills from other gymnastics disciplines, or in other sports, or even from a personal life such as sewing, drawing or play music. Different techniques and aesthetics can merge into new creations. There is no limitations to the GfA practice so individual experiences matter and can help the group development. In this sense, personal prior experiences in theatre, dance or music for instance should be considered an advantage to the group. When personal backgrounds add up, the choreography process can also be more creative.

beyond a simple “individual experience”, getting closer to what Benjamin (1999) called as “a shared experience”. In his book entitled “Experience and Poverty” (1999), Benjamin argues that experience is connected to communication and to the transmission of experiences down from one generation to the next using narratives, something that has been dramatically reduced in modern society, according to him. If the experience is related to act of sharing and to the ability to turn out “spontaneous narratives”, it needs to be a collectively constructed experience.

From the practical point of view, it is common to see GfA groups that have participants who have just joined the group and others whose participation has been going on for years. The relationships between the participants can be very complex, showing huge challenges in the sharing experiences process. In general, the most experienced group members usually take over the responsibility of sharing their knowledge with others, leading the process. However, the GfA groups are constantly exposed to renew and leverage by ideas coming from new members, so that we believe the dynamics of experience exchange seems to be strongly influenced by time, and therefore by the adherence and long-term participation.

Since cooperation and empathy, needed for the collectivity development, are slowly built, the time – or extended time participation – becomes a very important aspect (Sennett, 1998). Therefore, time has a wide role ensuring the engagement required for sharing experiences, especially when groups include novice gymnasts simultaneously with other more experienced. The newcomers need to recognize the situations already framed into the group finding the way and the time to bring their contributions. At the same time, experienced members need to be opened to new ideas and see the potential in contributions coming from the new ones. It

is really important to ensure an environment where all of them can express opinions and participate in group decisions.

In the opposite direction, short-term experiences often result in superficial relationship or convenient bonds (Sennett, 2012). Long-term adherence leads to more quality time spent together in the group. In other words:

Practice unfolds in time and it has all the correlative properties, such as irreversibility, that synchronization destroys. Its temporal structure, that is, its rhythm, its tempo, and above all its directionality, is constitutive of its meaning [...] In short, because it is entirely immersed in the current of time, practice is inseparable from temporality, not only because it is played out in time, but also because it plays strategically with time and especially with tempo (Bourdieu, 1992, p. 81).

Time should be considered as a key element for development of GfA, mainly when is known that social relations are hardly strengthened in short periods. Considering this, the GfA practice does not have to follow the pattern observed in competitive sport, which is often determined by the optimization of the use of time and with the pressure to make the processes faster and more efficient. Obviously, depending on the goals, structure, context and traditions of each group, the time management can change drastically. In this case, if the group’s approach to GfA is based on a high-performance mentality, focusing in the results, probably time will be strictly controlled to optimize its use. In cases like that, when the outcomes are a priority, the performance can be increased, but social development can be greatly impaired.

However, when GfA practice is developed in a longer and more flexible time, the characteristics of social relations change radically, providing space to participants’ diversity and heterogeneity. In this perspective, participants take the

time they need, which goes against current trends of focusing on the immediate moment (Sennett, 1998). It is also an opportunity to resist the pressure of modern life, when time is always short (Bauman, 2001; 2000). The logic of performance and productivity does not apply to GfA, where time is relative, and its control is not so stricted<sup>2</sup>. The discussion proposed by Sennett (1998) support our opinion on that:

One reason for this demeaning superficiality is the disorganization of time. Time's arrow is broken; it has no trajectory in a continually re-engineered, routine-hating, short-term political economy. People feel the lack of sustained human relations and durable purposes. The people I've so far described have all tried to find the depth of time beneath the surface, if only by registering unease and anxiety about the present (Sennett, 1998, p. 99).

To experience the "extended time", as suggested by Bauman (2000), first the group needs to want it. This decision requires from the members to be patient, flexible and opened to the dialogue: "the playing field of talk needs to be open and accessible" (Sennett, 1998, p. 109). Back to GfA, the collective process in extended time, enlarges the social relations development rather than short-superficial experiences. Therefore, we must be aware of the complexity of these relations, understanding that the "Groups tend to hold together through keeping to the surface of things; shared superficiality keeps people together by avoiding difficult, divisive, personal questions" (Sennett, 1998, p. 110). The challenge is the need to develop different ways in which participants can learn how to become part of the group, incorporating a cooperative way to work in order to improving their social abilities. We believe that the long-term participation is critical

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<sup>2</sup>Certainly, some Michel Foucault's ideas could contribute to the analysis, but this essay will not go further into this topic.

to increase the group engagement, to develop a collective sense and consequently to strengthen the recognition as well the sense of belonging. This extended time seems to be very important to establish stronger and stable social relationships.

### **GYMNASTICS FOR ALL AS A COUNTERPOINT TO THE INDIVIDUALIZATION PROCESS**

The emphasis on the process can reveal a unique feature of GfA: the power of the collective experience. The development of the sense of collectivity is directly linked to the long-term practice and the individual experience sharing. In this sense, the social relations experienced in GfA reinforce it as an educational tool for social development (Menegaldo, 2018).

Therefore, GfA becomes a practice that may oppose the individualization process prevalent in our society (Beck, 2003), process that is criticized by various sociologists (Bauman, 2000; Giddens, 1990; Flint & Powell, 2013; Lee, 2005; Schwartz, Coté & Arnett, 2005). According to Bauman (2001), the "individualized society" leads to excess, lack of time and creativity, immediatism and intolerance to difference. Based on the reproduction of traditional models and references, another important trend is relentless pursuit of the outcome.

As suggested by Parlebas (2001) theory, the cooperative practices that include GfA must be understood more than a simple PA or group sports practice. In other words, GfA practitioners can achieve improvements that go beyond the physical health benefits, as social recognition (Honneth, 1995), development of horizontal cooperative relations (Sennett, 2012) and social development (Bortoleto et al, 2019; Wichmann, 2014; 2015).

A long-term practice is important to increase communication skills and to develop a collective sense, encouraging people to spend time together and to foster

social relations through gymnastics. The extended time allows multiple and deeper individual experiences exchanges. So that, once the GfA group chooses a collective approach, the practice becomes dynamic, being constantly modified by its members. The GfA understanding proposed by us demands a deeply commitment from the gymnasts themselves (Sennett, 1998).

The mentioned commitment is related to the improvement of social skills, pushing participants to work together and to improve cooperation, empathy, and dialogic relationships (Sennett, 2012). It is associated with regular exercise of cooperation. Even more, it is about time and energy that the practitioners dedicate to the group, and therefore how much they engage themselves in the group tasks and activities. So that, even health and quality of life improvement are associated to the GfA practice (FIG, 2018), the development of social skills may represent the major impact of GfA for contemporary society. This is why it does not seem strange to us that social recognition and the sense of belonging become important motivations to the participants' engagement (Bortoleto et al., 2019; Wichmann, 2015).

We believe that GfA can be considered an alternative to the modern sports trends based in strict rules that lead to time control, precise scoring system, highlighting competition and performance (Guttmann, 1978). For those groups that find a way to develop the GfA social potential, through a flexible use of time and body, the cooperative experience can become an important motivation to have a long-life practice. In conclusion, GfA allows individual and social development, offering in many cases a deep collective experience to its participants.

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# HOW CAN WE ASSESS PHYSICAL LITERACY IN GYMNASTICS? A CRITICAL REVIEW OF PHYSICAL LITERACY ASSESSMENT TOOLS

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*Review article*

## **Abstract**

*Non-competitive gymnastics can contribute to the development of physical literacy (PL) that is widely recognized as a promising foundation of active living. Assessing PL is the first step for the design and evaluation of effective gymnastic programs aiming at PL enhancement, as well as for the empowerment of children's PL journey. This study attempted a comprehensive analysis of available PL assessment tools. Upon searching in five electronic databases, three multi-component tools that attempt to assess PL holistically and can be used in gymnastics were identified and were critically analyzed in relation to their content, target-population, feasibility and psychometrics. This process revealed that, despite their similarities, differences among assessment tools are evident, mainly on their primary focus, context(s) of application, age-groups they are designed for, criteria used for PL evaluation. Moreover, limitations were identified in every tool, including administration time; assessors' training required; not designed for individuals with disabilities; limited evidence for their psychometrics, raising concerns about those tools' feasibility, usefulness, and technical adequacy. As PL advancement demands valid and reliable assessment tools, the improvement of the existing ones to face their shortcomings and/or the development of new sound ones seems imperative.*

**Keywords:** *gymnastics, Physical Literacy Assessment tool for Youth, Passport for Life, Canadian Assessment of Physical Literacy, review.*

## **INTRODUCTION**

Across the globe, the elevating rates of childhood obesity (World Health Organization; [WHO], 2018) along with the predominance of physically inactive lifestyles among children and youth (WHO, 2018), are worrying phenomena related to health implications, such as cardiovascular (Cohen, 2004; Goran, Ball, & Cruz, 2003) and metabolic disease (Krekoukia et al., 2007; Singla, Bardoloi, & Parkash, 2010). As an answer to the above problems and their consequences, WHO (2018) highlights the value of both participating in regular physical activity (PA) and enhancing Physical literacy (PL).

As projected by the International Physical Literacy Association (IPLA, 2014) and also advocated by Canada's PL consensus statement (2015), PL can be defined as the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life. PL addresses a human "disposition" (Whitehead, 2013a, p. 29) and a personal lifelong journey (Taplin, 2013; Whitehead, 2013b), which relates not only to physical, but also to affective, cognitive and behavioral skills and characteristics (components of PL). The

interaction of these components which are shown to associate with children's PA participation (i.e. motor competence [Robinson et al., 2015; Venetsanou, & Kambas, 2017]; fitness level [Hands, et. al, 2009]; motivation/confidence [Cardinal, Yan, & Cardinal, 2013]; perceived motor skill competence [Barnett, et al., 2008]; heart-related fitness knowledge [Thompson, & Hannon, 2012]) is central to PL, contributing to its holistic nature. Although it is pertinent to all ages, PL promotion during childhood is of great importance since, during this period, health behaviors such as PA participation are formed (Pate et al., 2004).

Non-competitive forms of gymnastics, such as educational and recreational gymnastics, are ideal foundations for the reinforcement of PL (Baumgarten, & Pagnano-Richardson, 2010; Flemons, 2013). Several researchers have showed that gymnastics enhances children's motor competence (Culjak, Miletic, Kalinski, Kezic, & Zuvela 2014; Garcia, Barela, Viana, Barela, 2011; Fallah, Nourbakhsh, & Bagherly, 2015; Karachle, Dania, & Venetsanou, 2017; Kochanowicz, Kochanowicz, Niespodziński, Mieszkowski, & Sawicki, 2017; Yilmaz, & Sicim-Sevim, 2018); physical fitness (Akin, 2013; Lyulina, Zakharova, & Vetrova, 2013; Trajković et al., 2016) social and life skills (Baumgarten, & Pagnano-Richardson, 2010; Mandigo, Francis, Lodewyk, & Lopez, 2009; Shamshiri, Bagheri, Hashemy Doostan, & Yazdani, 2013). Most importantly, the specific forms of non-competitive gymnastics are assessible to all children regardless of their physical condition (Kalkhoran, Amini, Salman, & Zareiyan, 2018; Popescu, Dina, Stroiescu, & Dina, 2013). Gymnastics can contribute to the holistic development of each participant (Sloan, 2007), offering a context where every child can participate at his/her own level, set personal goals and satisfy his/her innate need of goal achievement, thus developing competence, motivation and

confidence for participation in a wide range of PA (Whitehead, 2010). Due to the aforementioned, gymnastics are thought to offer several benefits to children with disabilities (Campain, 2014), so it could be an ideal context for those children's PL development and PA enhancement (Dudley, Kriellaars, & Cairney, 2016; Longmuir, 2015).

If effective gymnastic programs aiming at PL enhancement are to be planned and implemented, PL assessment is the first step to be made. In that direction, PL holistic nature should be taken into account, so as the assessment to provide valuable information for identifying participants' progress and/or deficiencies on the whole construct of PL. In that way, participants' PL level would be fully depicted and individualized assistance could be provided to them, targeting on empowering specific physical, affective, cognitive and behavioral PL skills and characteristics. Moreover, the administration of valid and reliable holistic PL assessment tools would significantly contribute to the evaluation of gymnastics program' effectiveness. -This study aimed to gather, critically analyze and compare PL assessment tools, in an attempt to help researchers and professionals of gymnastics to select among them, according to their objectives.

## METHOD

Five electronic databases (Scopus, ScienceDirect, ERIC, PubMed and Google Scholar) were used to search the available literature about PL assessment tools. The main identifiers were "physical literacy" AND (assessment OR evaluation OR tool OR instrument). Only articles meeting the following criteria were selected for the review: a) published in peer-reviewed sources; b) written in English language; c) presenting a research study attempted to assess PL in children and/ or evaluating a PL program or describing the development and/or the standardization process of a PL

assessment tool. The search was conducted between the 2<sup>nd</sup> and the 12<sup>th</sup> September 2018. In the searching procedure no time limitation criterion was adopted.

From the above search 35 peer-reviewed articles rendered. Due to the small number of available articles an additional search, following a similar procedure, was applied to locate relevant theses and dissertations on Google Scholar. Four theses were located and added to the total. In addition, ten peer-reviewed articles were traced among the references of the above studies, increasing the number of the located studies to 49. Excluding three duplicated articles that were identified, the remaining studies were 46. The screening of those studies' abstracts resulted in the exclusion of four review studies and 12 studies that proved to be irrelevant to PL assessment. After the completion of the screening process a total of 30 studies remained and were examined in their full-texts for eligibility. In this final stage, it was concluded that ten studies did not meet the selected criteria for this review (i.e. present a research study attempting to assess PL in children and/ or evaluate a PL program or describe the development and/or the standardization process of a PL assessment tool). These studies were excluded (Figure 1).

## RESULTS

A total of 20 studies were included in this review study (16 peer-reviewed articles and four theses). Among them, 12 presented research studies focused on the PL assessment and/or the evaluation of PL programs, while eight provided information for the standardization/development of certain PL assessment tools. Almost all of the above studies were conducted in Canada, whereas only one took place in Northern Ireland.

Reviewing the above studies, it was revealed that two different approaches to PL assessment were evident. The dominant approach relates to the attempt of several

researchers to develop and use multi-component PL assessment tools (the studies reflecting this approach are presented in Table 1). Three Canadian multi-component tools were used in studies representing this approach: a) the Physical Literacy Assessment tool for Youth (PLAY tools; Canadian Sport for Life [CS4L], 2013), b) the Passport for Life, (PFL; Physical & Health Education Canada [PHE Canada], 2013) and c) the Canadian Assessment of Physical Literacy (CAPL; Healthy Active Living and Obesity Research Group [HALO], 2014).

The second approach in PL assessment can be identified in three studies (Buckler, et al., 2016; George, Rohr, & Byrne, 2016; McKee et al, 2013) in which a variety of standardized instruments (such as the Bruininks-Oseretsky Test [Bruininks, 1978], the Self-perception Profile for Children [Harter, 1985], or the Physical Activity Enjoyment Scale [Kendzierski, & de Carlo, 1991]) were used to assess one or more components of PL. However, those studies do not provide information about all PL components.

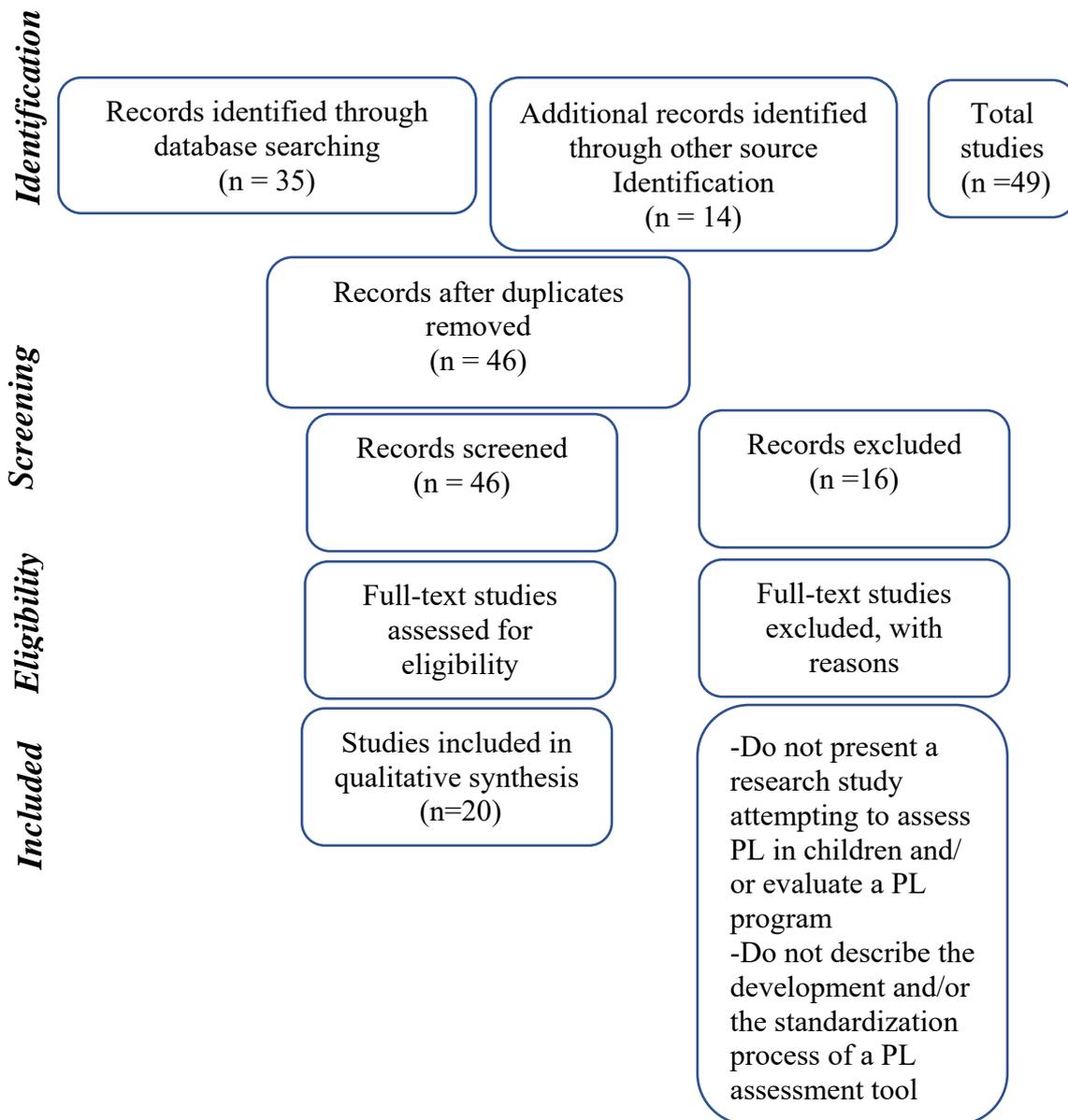


Figure 1. Process of screening and selecting studies for inclusion in the review (Moher, Liberati, Tetzlaff, Altman et al., 2009).

Table 1  
*Studies in which multi-component PL tools were used.*

	<b>Aim of the study</b>	<b>Authors</b>	<b>Tool</b>
<b>Studies presenting the development and/or psychometrics investigation of a PL tool</b>	• Examination of PLAYfun's construct validity	Cairney et al., 2017	PLAY
	• Presentation of PFL as a formative assessment	PHE, 2014	
	• Establishment of validation evidence for PFL as a formative assessment in relation to content, response processes, internal structure and associations with other variables	Lodewyk & Mandigo, 2017	PFL
	• Development of CAPL	Longmuir, 2013	
	• Development of the Canadian Agility and Movement Skill Assessment (CAMSA)	Longmuir et al., 2015a	
	• Examination of feasibility, objectivity and reliability		
	• Validity of CAPL scoring system	Longmuir et al., 2015b	CAPL
	• Investigation of CAPL theoretical model by an expert panel	Francis et al., 2016	
• Examination of age effect bias due to age grouping by cut-off dates on CAPL scores	Dutil, 2017		
<b>Studies focusing on PL assessment and/or PL program evaluation</b>	• Evaluation of PL in multiple education sectors	McCallum, & Sheehan, 2015	CAPL
	• Examination of validation of PL screening tasks	Alpous, & Longmuir, 2016	CAPL
	• Investigation of the relationship between PL elements and daily PA on weekends and weekdays	Gregg, & Hall, 2016	CAPL
	• Inspection of new correlates of children's PL	Lizotte et al., 2016	CAPL
	• Association between children's physical competence and their perceived adequacy and predilection for PA	MacDonald, Kays & Saunders, 2016	CAPL
	• Examination of the effect of exergames on PL	Thomas, 2016	CAPL
	• Associations between FMS and health indicators	Comeau et al., 2017	PLAY (specific protocols) PFL (specific protocols)
	• PL in children with physical disabilities	Dugas, 2016	PLAY (modified form)
• Assessment of PL in Canadian children/youth, evaluation of a PL intervention in PE	Kozera, 2017	PLAY	

Table 2  
*PLAY suite of tools.*

<b>Tool</b>	<b>Aim</b>	<b>Description</b>
PLAYfun	Assessment of motor competence, confidence and comprehension of performance	Tool of 18 fundamental movement skills/tasks; administered by trained professionals
PLAYbasic	Assessment of motor competence, confidence and comprehension of performance	Simplified version of PLAYfun, consisting of 5 fundamental movement skills/tasks; administered by trained professionals
PLAYparent	Assessment of parents' perceptions about child's fitness level; motor skills; motivation; confidence for PA; related knowledge; PA participation in different environments	20-item questionnaire; completed by parents
PLAYcoach	Assessment of coaches' (or other administrators') perceptions about child's fitness level; motor skills; motivation; confidence for PA; related knowledge; PA participation in different environments	17-item questionnaire; completed by coaches (or other administrators)
PLAYself	Assessment of children's self-evaluation of their motivation/confidence for PA, fitness level and interest in PL comparing to other school literacies, i.e. literacy and numeracy	22-item questionnaire; completed by children
PLAYinventory	Recording of children's leisure-time activities throughout the year	List of 95 potential activities; completed by children or anybody from their environment

Table 3  
*PFL assessment components.*

<b>Components</b>	<b>Aim</b>	<b>Description</b>
Active Participation	Assessment of variety/frequency/different environments of PA participation and interest/intention for PA	On line 21-item questionnaire; completed by students
Living Skills	Assessment of motivation for PA (e.g. feelings of enjoyment, self-efficacy, anxiety, autonomy, perceived value of PA) and variety of skills (e.g. conceptual knowledge, critical thinking, problem solving, goal setting, self-regulation, interacting skills)	On-line 21-item questionnaire; completed by students
Fitness Skills	Assessment of cardiovascular endurance, balance/dynamic stability, core muscle endurance	Set of fitness tests including a 4-station sub-maximal exertion circuit, a lateral bound test, and a front plank test; administered by physical education/health teachers
Movement Skills	Assessment of lower limb object manipulation, upper limb object control, locomotion	Set of tasks including kicking, throwing/catching, and running; administered by physical education/health teachers

Table 4  
CAPL domains.

Domains	Aim	Description
Daily Behavior	Assessment of PA levels and sedentary behavior	Information is gathered through: <ul style="list-style-type: none"> <li>– Pedometers</li> <li>– 5 items of CAPL PA questionnaire</li> </ul>
Motivation and Confidence	Assessment of perceived motor competence, adequacy, predilection for PA	Information is gathered through: <ul style="list-style-type: none"> <li>– 16 items of CSAPPA (Hay, 1992)</li> <li>– 4 items of CAPL PA questionnaire</li> </ul> Completed by children
Physical Competence	Physical fitness	Set of standardized protocols: <ul style="list-style-type: none"> <li>– PACER shuttle run (Scott, Thompson, &amp; Coe, 2013),</li> <li>– Grip strength (Tremblay et al., 2010),</li> <li>– Plank (Boyer et al., 2013),</li> <li>– Sit and reach (Tremblay et al., 2010),</li> <li>– Weight, height, waist circumference</li> </ul> Administered by a trained adult
	Motor Competence	Assessment of fundamental, combined, and complex movement skills
Knowledge and Understanding	Assessment of heart-related fitness knowledge and safety issues	10 items of CAPL PA questionnaire; completed by children

The presence of different approaches to PL assessment is not surprising since research in the area is still in the developmental and explanatory stages. Besides, the range of available PL assessment tools is restricted and only prevalent to Canadian settings. This limitation may have led some researchers to select some of the commonly used tools and use them to assess some components of PL. Finally, the initial lack of consensus on the interpretation of the PL concept, the range of skills and characteristics it encompasses and how these are weighed within it, which have already been noticed by Edwards et al. (2017), may be an explanation for the differentiation in the PL assessment methodology. For example, most commonly, PL is mistakenly associated with the Fundamental Movement Skills (FMS), thus mainly focusing on the promotion of motor competence (Almond, 2013). However, this implies a narrow perspective of PL and inevitably results in its deficient

assessment because essential components of PL are excluded. As reported earlier in this article, PL is a holistic concept, thus pertinent assessments must refer to its multidimensional and holistic nature and attempt to measure it entirely as a composite entity. Therefore, this review will focus only on the three aforementioned Canadian multi-component tools (i.e. PLAY, PFL and CAPL). Each tool's manual(s), website and research papers referring to their development/standardization are used as primary sources for their presentation below. Relevant information deriving from literature is also discussed.

### MULTI-COMPONENT PL ASSESSMENT TOOLS

#### *Physical Literacy Assessment for Youth (PLAY tools)*

The PLAY suite of tools, also referred as PLAY, is a PL assessment for children 7 years and older, developed by Kriellaars

for Canadian Sport for Life (CS4L, 2013), a non-profit organization that is devoted to enhancing active living and health through sport/PA and PL programming (CS4L, n.d.).

PLAY (<https://play.physicalliteracy.ca/>) can be applied for research purposes, program evaluation, engagement in PA and also for surveillance and awareness about PL among population and the leaders, aiming at contributing to either individual or group programming for PL enhancement among the young population.

PLAY consists of six independent tools (PLAYfun, PLAYbasic, PLAYparent, PLAYcoach, PLAYself and PLAYinventory) (Table 2) which can be either applied separately or in combination to assess the different components of a child's PL (CS4L, 2013). Among them, PLAYfun and its simplified version, PLAYbasic, are considered the main assessments, while PLAYparent, PLAYcoach and PLAYself function as their supplements (CS4L, 2013). Recently, Cairney et al. (2018), who are involved in PLAY's validation, stated that PLAYpe for Physical Education (PE) teachers and PLAYcreativity will be added to the suite of PLAY tools. However, no further clarifications were given about what these assessments entail, while there is no reference of them in the relative website.

The administration of PLAYfun (and PLAYbasic) requires an indoor or outdoor activity space with cones and balls. The administrator, based on specific criteria, evaluates the ability of the child to perform every single task, marking his/her performance in a visual analogue 100mm scale. Top scores represent proficiency of the task as required in the sport context regardless of the examinee's age. Moreover, the examinee's level of confidence and comprehension of the performance is recorded but not scored. PLAYbasic provides a total score which is the sum of the five tasks scores; whereas PLAYfun provides also subsection scores (running, locomotor, object control – upper

body, object control – lower body, balance, stability & body control), which are summed to provide total PLAYfun score. The examinee's performance level can be characterized as Developing (including Initial [0-25mm] and Emerging [25-50mm] level) or Acquired (including Competent [50-75] and Proficient [75-100] level). Regarding PLAYfun's completion time, no clear estimation is given. However, in their critique about Canada's PL assessment tools, Robinson and Randall (2016) estimated that the administration of PLAYfun in a group of children equal to a school class would take approximately four class sessions.

PLAYparent, PLAYcoach and PLAYself questionnaires are completed via paper. For PLAYparent and PLAYcoach, questions are summarized in four subsections (i.e. cognitive, motor competence, environment and fitness). In PLAYself, relative information is also gathered in four subsections (i.e. environment, PL self-description, relative ranking of literacies and fitness). Subsections scores (all but fitness) are summed to provide a PL score for each tool. PLAYinventory, though taken into consideration, is not scored. PLAY does not provide a composite score resulting from the combination of all PLAY tools scores; however, coaches and parents/guardians are advised to compare PLAY tools outcomes to gain a better insight into a child's PL. Moreover, a list of recommendations and actions to take in order to improve PL correspond to each PLAY tool score. Finally, comparisons between children are not recommended; instead, tracking forms are provided in order to detect individual weaknesses that can be improved by establishing realistic goals for each child (CS4L, 2013).

As far as PLAY's technical adequacy is concerned, only PLAYfun gathers published evidence for its psychometrics in ages 7-14 years, since recently two aspects of its construct validity (factor structure; score variation in relation to sex and age)

were examined by Cairney et al. (2018). According to the confirmatory factor analysis results, the hypothesized model of the five domains within PLAYfun (running, object control – upper body, object control-lower body, locomotion, and balance) was supported (RMSEA = 0.055, 90% CI = 0.03 to 0.075; CFI=0.95; TLI=0.94); whereas PLAYfun score differentiated children's performance according to patterns observed in literature, i.e. motor skill performance improving with age (Payne, & Isaacs, 2011) and boys performing better than girls only in the object control domains (Barnett et al., 2010). No other PLAY assessment is technically supported at the moment. In respect of PLAY's use in research, in its website (<https://play.physicalliteracy.ca/>) it is stated that it has been implemented to assess PL of over 25,000 children and youth across Canada; however, there is no published data to support this statement.

It seems that PLAY can be used for the assessment of young children participating in gymnastics at school or other recreational settings. The space and the equipment required for PLAYfun application can be found easily in most of the gymnastic settings. Moreover, PE specialists and coaches could be potential administrators with the proper training. The movement skills/tasks selected for assessment, e.g. run, jump, land on two feet, skip, gallop, hop, one-handed catch, balance walk (heel-to-toe), lift and lower etc., are fundamental for the learning of more complex tasks taught in gymnastics. Since gymnastic programs include task performances requiring locomotor, object control, and stability skills, professionals who work with young gymnasts can apply an assessment like PLAYfun that covers a large range of such skills.

What is more, additional information, e.g. participants motivation and confidence for PA, comprehension of movement terms etc., which can be gathered by PLAYcoach, should be of some concern for the professionals of gymnastics, who

aim at the holistic development of the young participants. Moreover, the potential involvement of children's parents/guardians in the assessment by the application of PLAYparent could provoke their awareness on the importance of participating in gymnastics at any level. Alike, PLAYself and PALYinventory could be used by those concerned as a motivational tool for maintaining young participants' engagement with gymnastics and PA. It should be mentioned that for a PE specialist or a professional of gymnastics it will take a considerable amount of time to gather information from all the PLAY tools. However, the combination of PLAYfun and PLAYcoach would compromise the time burden and provide them with valuable information that could be used for the enhancement of their participants' PL.

#### ***Passport For Life (PFL)***

PFL is a formative PL assessment that was launched in 2013 by the professional organization for physical and health educators of Canada (PHE Canada, 2013). It is actually a curricular-based program designed to stimulate awareness, assessment, development and advancement of PL in the educational context, among teachers and their students (PHE Canada, 2014). An alternative goal of PFL is to accumulate data over time that will facilitate the information of the public or other stakeholders about the level of PL among children and youth. PFL has been designed for students across the grades 3 to 12 (ages 8-18), while it will soon be available for the first grades (1 to 2, ages 6-8) and the kindergarten (ages 5-6) (Dutil, 2017; Lodewyk, & Mandigo, 2017). PFL (<http://passportforlife.ca/>) assesses PL in four distinct components: a) Active Participation, b) Living Skills, c) Fitness Skills and d) Movement Skills. A summary of PFL components is provided in Table 3.

The tests used for the assessment of fitness and movement skills respectively are administered during the PE class and

require an activity space (indoor or outdoor) along with cones and balls. Movement tasks are combined and performed in a dynamic activity environment, so that students' ability to adjust their movement according to changing conditions is identified. These activities are modified in relation to the grade (Lodewyk, & Mandigo, 2017). Students' performance on each fitness/movement skill is graded according to criteria provided and located into one of the four PL levels/categories (Emerging, Developing, Acquired and Accomplished), in line with curricula objectives for their age. PFL questionnaires' scores are independent of the above fitness/movement one; a composite PFL score is not calculated as, according to PFL authors, PL is a complex concept and PFL is just a close reflection of students PL; it does not represent the entire picture of it (PHE Canada, 2013). With regard to PFL administration duration, if a single assessor is available, the amount of time needed for the completion of all the assessments is considerable. In the research of Lodewyk, & Mandigo (2017), a wide range of completion time is reported (2.5 to 6 PE sessions). However, this time can be shortened as there is the choice for students to complete the on-line questionnaires either during or after school hours.

The PL assessment with the PFL within Canadian educational context is held twice a year; at the start and near the end of each school year or semester. An electronic registration is necessary to input and administer students' data. After creating on-line profiles for each student, teachers are able to download the Teacher's Guide, which helps them to organize the assessment, interpret the results and implement personalized strategies to encourage their students' PL. Once they complete each round of assessments, students receive a Passport with summary of individual data, as well as suggestions for personal improvement.

This informative document, which is not a grade for the PE course, is also accessible to parents/guardians. Additionally, a database with students' assessment results across multiple years is provided. A Class Passport, which summarizes students' results, is also generated by the system to assist teachers set attainable goals for their group of students.

With regard to PFL psychometrics, Lodewyk, & Mandigo (2017) gathered evidence for its use in grades 3 to 6 (ages 8-12) and 7 to 9 (ages 12-15), both through a preliminary (n=860) and a full-scale study (n=5110). Starting with content validity, authors state that it was established by a process of consultation, involving PE experts from across Canada. Additionally, statistically significant ( $p < 0.001$ ), although weak to moderate, correlations were revealed between movement and fitness tests scores ( $r = 0.28-0.45$ ) and between those scores and students' self-reported participation in fitness activities at school ( $r = 0.11-0.20$ ,  $p < 0.01$ ). Moreover, the factor structure of living skill component was investigated through an exploratory factor analysis (factor loadings 0.53-0.81; variance explained 42.07-54.53%). Finally, response process evidence was gathered and it was found that students across all grades easily comprehended and were able to complete all assessments, while teachers found PFL to be relevant and easily administrated. More than 80% of the teachers considered that PL was better understood by the students after the assessment procedures and that the outcomes would help them enhance their PL (Lodewyk, & Mandigo, 2017). In reference to PFL's reliability, Lodewyk, & Mandigo (2017) examined interrater (ICC=0.65-0.82) and test-retest reliability ( $r = 0.72-0.89$ ) for the fitness and movement PFL components, whereas they report that most of the PFL assessment scales presented a sufficient stability and internal consistency between fall and spring assessment times within an academic year.

As far as PFL's use in research is concerned, it is limited, although the tool is widely used within Canadian educational context (Mandigo, et al., 2013). Only PFL movement and fitness skill components have been used in FMS research so far (Comeau et al., 2017).

In the school environment, students have the opportunity to engage with several sport/PA, with gymnastics to be one of those. PFL can be used to assess basic movement skills, e.g. kicking, throwing/catching, running etc., that are necessary building blocks for educational gymnastics, as it is for every PA. Given that the participation in gymnastics and in most of the PA practices is facilitated by the good physical condition of the participants, the assessment of their fitness is important and can be easily conducted by PFL. It should be noted that the PE specialists should have been trained to conduct such assessments and the school gyms are the proper environments for them to use.

Furthermore, PFL can provide multiple information for a variety of living skills, which are essential for every student participating in educational sport programs. Particularly, skills, such as critical thinking, problem solving, goal setting, self-regulation included in PFL, it is important to be assessed if intelligent participants are to be developed. In addition, through PFL, significant affective skills and characteristics, e.g. self-efficacy, anxiety, autonomy, perceived value of PA etc., are evaluated, offering the PE specialists a rich pool of useful information. Such an information can be used to enhance the motivation and confidence of their students to participate in various PA, including the demanding activity of gymnastics. However, it should be taken into consideration that the completion of all the PFL assessments could be time-consuming due to the limited availability of PE specialists in schools.

### ***Canadian Assessment of Physical Literacy (CAPL)***

The Healthy Active Living and Obesity research group (HALO) has been systematically involved in the development of CAPL tool since 2008 (HALO, 2014). According to Longmuir et al. (2015b) the fundamental goal of CAPL's developers is to offer a valid and reliable tool to monitor children's PL (target age range: 8 to 12 years old) within sport, recreation and educational contexts (<https://www.capl-ecsf.ca/>). In an attempt to represent PL's definition, CAPL assesses a wide variety of skills, characteristics and active habits of the child in four domains: a) Daily Behavior, b) Motivation and Confidence, c) Physical Competence, and d) Knowledge and Understanding (Table 4). For CAPL's development, its authors used both standardized tools (e.g. Children's Self-Perceptions of Adequacy in and Predilection for PA questionnaire [CSAPPA]; Hay, 1992) and created new ones (the Canadian Agility and Movement Skill Assessment [CAMSA]; Longmuir et al., [2015a] and the CAPL PA questionnaire [Longmuir et al., 2015b]). According to Tremblay and Longmuir (2017), a new shortened version of CAPL (CAPL-2) is in progress; however, as there is no data regarding this version so far, this study has focused on the original version of CAPL (HALO, 2014).

A gymnasium or an open activity space with hula hoops, cones, balls, CD player, sit and reach flexometer, handgrip dynamometer, etc. is necessary for administering CAMSA and physical fitness assessments, whereas pedometers should be worn for seven consecutive days. According to CAPL's authors (HALO, 2014), teachers, PA professionals, public health practitioners, recreational leaders, even parents/guardians can administer CAPL protocols as long as they undergo appropriate training, whereas CAPL questionnaires can be completed on-line by utilizing hand electronic devices (e.g. tablets).

Each child's performance in CAMSA is assessed through the time needed for its completion and the quality of movement skills execution, assessed according to detailed criteria. Detailed description of the procedures and evaluation criteria for the fitness tests are also provided. Each child's scores in all CAPL tasks and questionnaire items are summed into the PL domains described above and a total CAPL score is then computed (Francis et al., 2016). Due to an algorithm provided by the manual (2014), this total score can be calculated even if one domain score is entirely missing. A child's total CAPL score can be classified into four categories (Beginning, Progressing, Achieving and Excelling) reflecting the child's PL current level in regard to his/her age and gender (HALO, 2014). Interpretive remarks and general suggestions for encouraging PL accompany each of the above levels. Apart from the total CAPL score, each domain score, as well as each individual protocol score within a domain can be interpreted independently, according to the child's age and gender, enabling the assessor to pinpoint deficits on specific aspects of child's PL. In relation to CAPL's administration duration, excluding the one-week period of pedometer activity measurement, the completion of all protocols by one child takes approximately 60 minutes; whereas for a group of 25-30 children with one or two assessors available, four days with a 30-40-minute session/day are needed. That means that CAPL's administration is lengthy and cannot be easily conducted by a single assessor, as also Longmuir et al. (2015b) acknowledge.

In regard to its technical adequacy, CAPL's theoretical PL assessment model approved by Francis et al. (2016), was tested and supported by Longmuir et al. (2015b) through confirmatory factor analysis (Goodness of Fit Index=0.96; Bentler Comparative Fit Index=0.94; Bentler-Bonett NFI=0.91; Bentler-Bonett Non-normed Index=0.91; RMSEA=0.057).

In the study of Longmuir et al. (2015b), it was also found that CAPL raw scores follow expected patterns according to age and gender; whereas interpretive categories (in relation to age and gender adjustive normative data) revealed no association with age. Moreover, the total and most domains scores of participants were significantly associated with their teachers' ratings, supporting CAPL's convergent validity. Dutil (2017), who investigated the potential age effect bias in CAPL (due to grouping by cut-off dates), came to the conclusion it is not affected and therefore is a valid measurement of children's PL. Finally, the technical adequacy of CAMSA (Longmuir et al., 2015a) was examined and it was proved to be a valid, objective, reliable and feasible measure of the specific combination of fundamental, complex and combined movement skills it contains (Longmuir et al., 2015a)

In respect of the use of CAPL in research, it is true that CAPL appears in several studies. Among them, some utilized CAPL to assess children's PL (McCallum, & Sheehan, 2015), investigate the relationships among its components (Gregg, & Hall, 2016; Lizotte et al., 2016; MacDonald, Kays, & Saunders, 2016) and evaluate the impact of interventions (Thomas, 2016). Apart from the above, CAPL was used in two cross-cultural studies. One conducted in Kenya (Tremblay et al., 2014), comparing CAPL scores between Canadian and Kenyan children and one conducted in South Africa (Uys et al., 2015), attempting to investigate the validation of key-components of CAPL in local 10-year-old children. Finally, CAPL used as a criterion for the examination of sensitivity and specificity of PL screening tasks (Alpous, & Longmuir, 2016).

Alike PLAY, CAPL can be used in gymnastics within several settings, e.g. education, recreation; however, the difference between the two is that, CAPL can directly assess the children's performances and responses, whereas

PLAY also uses other people's beliefs about them. Although, CAPL does not include additional assessments from parents and coaches, completion time still remains a problematic issue, because at a recreational level or at the school environment the weekly participation is limited to a few sessions. Other administration issues, such as the availability of more than one assessor and the demanding training of them on the CAPL protocols could be of some concern, but in most of the gymnastics settings these issues could be manageable. Additional concern could be the provision of pedometers; however, their usage is a pleasant experience for the young participants and enhances their motivation to take part in the assessment. Other equipment and the activity space required for the application of CAPL protocols are typically available in the gymnastic settings.

It is worth mentioning at this point that CAMSA, CAPL's movement skill assessment, is developed to assess a sequence of movement skills performed in a dynamic environment, offering this way an alternative form of assessment. Control of acceleration/deceleration, rhythmic movement, balance, core stability, coordination, equilibrium, precision, are within the complex and combined skills included in CAMSA and are designed to simulate the real conditions that participants face during their practice in gymnastics and in several other PA. Furthermore, through CAPL's fitness protocols professionals of gymnastics can obtain multiple useful information about their participants' fitness status, e.g., about their cardiovascular endurance, strength and flexibility, with the aim of improving their overall fitness. Considering that the weight status of the participants in gymnastics is of great interest and also relates to better health, the somatometric information gathered through CAPL is critical.

## DISCUSSION

The aim of the present study was to review PL assessment tools in an attempt to provide those who are involved in non-competitive gymnastics with a useful stepping stone for selecting the appropriate tool for their objective(s). After reviewing relevant literature, it was found that only three tools were purposely designed to assess PL, and those were PLAY (CS4L, 2013), PFL (PHE Canada, 2013) and CAPL (HALO, 2014). All of them are multi-component tools that address the variety of PL components described in IPLA's (2014) definition and were initiated by the efforts of Canadian research groups. Canada's progress in PL assessment is justifiable, since the country has dynamically embraced the concept and implicated it in education, sport development and recreation (Spengler, 2015). Besides, the development of PL assessment tools was among the objectives of the Canada's PL consensus statement (2015), endorsed by the Public Health Agency of Canada and signed by many domestic organizations.

From this review it becomes clear that PLAY, PFL, and CAPL represent a meaningful effort to contribute to PL assessment and advancement at an individual and societal level and can be used in gymnastics. The similarities that these tools share are several, e.g. identification of PL deficits, encouragement of individual progress, tracking of PL over time; it is more informative, however, to discuss their differences. Starting with the content of the assessments, a different philosophy is observed among them, as each tool assesses an alternative combination of skills, characteristics and behaviors attributed to PL. Being an educational tool, PFL focuses on the all-round development of the child in the physical, cognitive and psychosocial domain. Communication skills and features, such as goal-setting or self-regulation, detected in PFL living

skills component, emphasize its holistic nature. On the other hand, CAPL puts greater emphasis on the PA behavior and physical competence domain, including pedometers as an objective measure of PA, lots of fitness tests, and anthropometric measures. As far as PLAY is concerned, although it seems that by the combination of all the PLAY tools the core PL components are addressed, its main assessment, i.e. PLAYfun, is movement skill-oriented and vaguely succeeds to encompass the affective and cognitive PL components.

With respect to the population these tools are designed for, PFL can be utilized only in the school context, across all grades (3-12, ages 8-18); whereas PLAY and CAPL can be applied in various contexts, e.g. sport, education, after school-programs, recreation, to assess PL across different age ranges. Between the last two, CAPL concerns the assessment of children of a limited age range (8-12 years), while PLAY is applicable both in children and youth. At this juncture, PL assessment in children with disabilities should be discussed, as a research shortcoming is noticed regarding assessment tools aiming at assessing PL in individuals with disabilities. Only Dugas (2016) piloted an assessment tool for children/youth with physical disabilities by modifying elements of PLAY. In reference to the original PLAY, PFL and CAPL, they are not designed to cover PL evaluation of children with disabilities. Nevertheless, both CAPL's (HALO, 2014) and PLAY's (CS4L, 2013) developers acknowledge the necessity to facilitate these children's PL assessment; whereas at PLAY's website (<https://play.physicalliteracy.ca/>) the initiations of research procedures to develop assessments for individuals sitting on wheelchairs, having limited mobility, cerebral palsy and autism are announced. Moreover, at PFL website (<http://passportforlife.ca/>) it is stated that PFL assessments are possible to be

adjusted for children with mobility impairments or cognitive/behavioral challenges. From the above it can be concluded that although the importance of PL assessment in disabled children is recognized, there is a long way ahead for the publication of sound PL tools for this population. Nevertheless, the need for further research on this topic is imperative, since the exclusion of disabled children from assessment procedures eliminates their opportunities to make improvements in their PL.

In terms of PL tools' administration, although there is evidence for their feasibility (Cairney et al., 2018; Lodewyk, & Mandigo, 2017; Longmuir et. al., 2015b), few problematic areas should be discussed. An important drawback of PLAY, PFL, and CAPL is that they are time consuming; therefore, their repetitive application to track PL overtime may be discouraging. The availability of many assessors could moderate the problem; however, at most of the PA settings, especially at school, the engagement of many assessors is difficult, if not impossible. Nevertheless, it should be mentioned that, although the elimination of the administration time is important for measurement feasibility, the multidimensionality and the holistic nature of these tools should not be compromised by future modifications on them. Another issue that should be noted is assessors' training required for their administration. Although PFL can easily be applied by PE educators with no additional training on the assessments (Lodewyk, & Mandigo, 2017), potential assessors of CAPL should undergo thorough training on its protocols, whereas PLAY's main assessments can only be applied by trained PA professionals.

In regard to motor competence assessment, although specific criteria are described by each PL tool, there are concerns about their objectivity. Starting with PFL, Dutil (2017) reports that it allows subjective movement skill

assessment. Moreover, in PLAY's movement skills component, the considerable large score scale (0-100) seems to lead to a relatively subjective assessment. However, in CAPL, detailed criteria provided for movement skills assessment do not allow for the assessor's subjective decisions. Additionally, the interpretation of each examinee's performance is not the same across all tools. For PFL and CAPL, skills performance is interpreted in relation to age, whereas for PLAY, proficiency in a task requires athletic performance regardless examinee's age. Although Cairney et al. (2018) advocate that PLAY's scaling, based on predetermined outcomes (e.g., such as the time of completing a task), is advantageous comparing to others, the fact that PLAY's results are not age corrected can lead to misconceptions, as also Robinson and Randall (2016) highlight.

The last but of equally importance issue that should be discussed is PL assessment tools' psychometrics. Among the three tools reviewed in this study, PLAY is that most lacking evidence for its technical adequacy, as only construct validity for one of its tools (PLAYfun) has been examined in children 7-14-year-old (Cairney et al., 2018) and not in its entire target-age range. PFL presents published evidence regarding its content and construct validity as well as its reliability (stability; internal consistency); however, construct validity has not been investigated for the PFL as a whole; instead, different criteria were examined for different PFL components (internal consistency was examined only in movement and fitness components; factor structure was examined only in living skill component) (Lodewyk, & Mandigo, 2017). Furthermore, the above evidence refers only to students of grades 3 to 9 (ages 8-15), although PFL aims at assessing PL in grades 10-12 (ages 15-18) too. CAPL is the only tool with published evidence in regard to the validity (construct validity; convergent validity) of

the entire instrument as an entity (Dutil, 2017; Francis et al., 2016; Longmuir et al., 2015b) in children aged 8-12 years old, whereas separate data are available for CAMSA's validity and reliability (Longmuir et al., 2015a). However, until now there is no information regarding the reliability of CAPL, which is of concern for its use when repeated measures are needed. From the above it is obvious that among the three, CAPL's technical adequacy is better supported; however, due to their recent development, the research behind PLAY, PFL and CAPL continues. Further research is needed so that their validity and reliability can be established.

Taking the aforementioned into account, it is obvious that despite the significant contribution of these tools to PL assessment, additional improvements should be made. As PL gains attention around the world, feasible, non-costly, valid, reliable and culturally-relevant PL tools are needed. By this means, people who teach gymnastics would be able to easily, effectively and frequently implement the suitable assessment procedures to ensure progress in PL of young participants.

## CONCLUSIONS

Up to the present, the assessment of PL is at a beginning stage with no gold standard to follow. This review revealed that there are three multi-component tools (PLAY, PFL, CAPL) initiated in Canada that were designed to address the interactive components within PL. These holistic tools are currently leading the way in PL assessment and are already being used in several contexts with the aim of promoting PA participation. Thus, they can be used in gymnastic programs to facilitate learning evaluation and monitoring. In line with their objectives, PFL can be utilized in educational gymnastics; whereas the other two can be used both in educational and recreational gymnastics. In addition, these tools can also be used for research

purposes. The critical analysis of them in relation to content, target-population, feasibility and psychometrics, despite observing their similarities, highlighted their differences mainly in terms of primary focus, context(s) of application, age-groups they are designed for and criteria used for physical literacy evaluation. Limitations were also identified including administration time; assessors' training required; not designed for individuals with disabilities; limited evidence for their psychometrics, raising concerns about those tools' feasibility, usefulness and technical adequacy. Nevertheless, research behind (and with) PLAY, PFL, and CAPL continues. As PL advancement demands valid and reliable assessment tools, the improvement of the existing ones to face their shortcomings and/or the development of new sound ones seems imperative.

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# THE RELATIONSHIP BETWEEN PASSION AND IMAGERY USE IN COMPETITIVE YOUTH GYMNASTICS

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*Original article*

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## **Abstract**

*The purpose of the present study was to examine the relationship between passion and imagery use in competitive youth gymnastics. The participants included 245 (male,  $n = 10$ ; female,  $n = 235$ ) gymnasts between the ages of 7-16 years participating in women's artistic gymnastics ( $n = 221$ ), men's artistic gymnastics ( $n = 7$ ), as well as trampoline and tumbling ( $n = 17$ ). Athletes completed questionnaires measuring the frequency of imagery use and their passion towards the sport of competitive gymnastics. A series of multiple regression analyses indicated that both harmonious and obsessive passion were significantly related to all five types of imagery. More specifically obsessive passion was most strongly associated with four of the five types of imagery (CS, CG, MS, and MG-A), and harmonious passion was most strongly associated with one of the five types of imagery (MG-M). Results and implications of passion and imagery use in competitive youth sport are discussed.*

**Keywords:** *imagery, passion, youth sport, gymnastics.*

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## **INTRODUCTION**

Competitive youth gymnastics begins at an early age, with girls reaching their gymnastics peak earlier than boys. It is not uncommon to see gymnasts engage in intensive physical training (20-30 hours per week) and psychological skills training as a result of their devotion to the sport (Cogan, 2006). In addition to the several hours of daily training (most days of the week), competitive gymnasts are expected to compete throughout the season, including qualifying competitions with the goal of making it to Provincial or National championships. As a result, families often make sacrifices including family activities, transportation to and from the gym, as well as costs of training and uniforms (Cogan & Vidmar, 2000). Thus, competitive youth gymnasts need to be very passionate about

the sport in order to allow for sustained engagement.

Philosophers have suggested being passionate about something is what it means to be human (Vallerand, 2012), and it is what makes people's lives most worth living (Vallerand, 2008). Philosophers suggest that without passion for activities, people would lack meaning in their lives (Curran, Hill, Appleton, Vallerand, & Standage, 2015). Thus, passion for a sport/activity is important to understand as it guides behaviour and provides motivation for sustained engagement. Passion can be defined as a strong inclination toward a personally meaningful, self-defining, and highly valued activity that one loves, finds important, and to which substantial time

and energy is invested (Vallerand et al., 2003; Vallerand, 2012). Passion can provide an autonomous, balanced, purposeful life by influencing motivation towards task-engagement and satisfying basic psychological needs. However, passion can manifest itself in compulsive and rigid behaviours whereby one feels controlled by the activity. The Dualistic Model of Passion (Vallerand et al., 2003; Vallerand, 2008) advances two types of passion that are non-dichotomous. Harmonious passion is thought to emerge from an autonomous full behavioural integration of an activity into one's identity. Harmonious passion is experienced through an activity in which one participates because it reflects what they like about themselves and complements other activities in their life. Obsessive passion reflects rigid persistence to engage in an activity because they cannot help themselves. This occurs when the activity becomes controlling over the person and can cause inner conflict with one's pre-existing values and beliefs and interferes with other important aspects in their life (e.g., family, friends, work, school, other interests). This occurs from an over-representation of the activity into one's identity and thus thwarts basic psychological need fulfilment.

The manifestation of passion for different activities can lead to either adaptive or maladaptive outcomes. Previous passion researchers have found links between passion to adaptive outcomes such as deliberate practice (Vallerand et al., 2007), improved performance (Vallerand et al., 2008), positive affect (Mageau & Vallerand, 2007), positive well-being (Rousseau & Vallerand, 2007), basic need satisfaction (Paradis, Cooke, Martin, & Hall, 2014), and team cohesion (Paradis, Martin, & Carron, 2012). Conversely, researchers have found that passion can also lead to maladaptive outcomes such as exercise dependence (Paradis, Cooke, Martin, & Hall, 2013), athlete burnout (Kent,

Kingston, & Paradis, 2018), team conflict (Paradis, Carron, & Martin, 2014), rigidity and inflexibility (Rip, Fortin, & Vallerand, 2006), rumination (Carpentier, Mageau, & Vallerand, 2012), life conflict (Vallerand et al., 2003), and negative emotions (Phillipe et al., 2010). In a meta-analysis on passion, researchers highlighted that harmonious passion is more commonly linked to adaptive outcomes from sport activity engagement such as positive affect and satisfaction, while obsessive passion is more commonly linked to maladaptive outcomes such as negative affect and rumination (Curran et al., 2015). However, these findings are not universal for each type of passion. In the context of high-performance sport, obsessive passion is often necessary to reach high levels of achievement. However, this does come at a cost, with potential negative influences on overall well-being.

Similar to passion impacting outcomes in sport, imagery has also been found to impact cognitive, behavioural, and affective outcomes in sport (Munroe-Chandler & Guerrero, 2017). Imagery is defined as creating or recreating an experience in one's mind (Vealey & Greenleaf, 2010). Researchers have noted that gymnasts engage in frequent imagery use (Calmels, D'Arripe-Longueville, Fournier, & Soulard, 2003; White & Hardy, 1998). In fact, Cogan (2006) has noted that "imagery is a top-priority mental skill in gymnastics" (p. 649). In qualitative studies, gymnasts have reported using various types of imagery for both training and competition (White & Hardy, 1998) and for dealing with fear of injury in their sport (Chase, Magyar, & Drake, 2005).

The majority of imagery research has stemmed from Paivio's (1985) analytic framework. The framework depicts that imagery is cognitive or motivational in nature and can operate on a specific or general level. Cognitive Specific (CS) imagery includes images of specific sport skills or techniques (e.g., doing a back walkover), whereas Cognitive General

(CG) imagery includes images of game plans, strategies or routines (e.g., gymnastics beam routine). Motivational Specific (MS) imagery includes images of an individual goal (e.g., winning a medal at a competition), whereas Motivational General (MG) imagery includes images of physiological arousal levels and emotions (e.g., feeling calm and relaxed in front of a crowd). This conceptualization of MG imagery was further differentiated between arousal and mastery (Hall, Mack, Paivio, & Hausenblas, 1998). Motivational General-Arousal (MG-A) imagery includes images associated with arousal and stress (e.g., being excited about competition), and the Motivational General-Mastery (MG-M) imagery includes images associated with being mentally tough, self-confident and in control (e.g., being focused in tough situations).

Children as young as seven years old engage in imagery use in sport (Munroe-Chandler, Hall, Fishburne, & Strachan, 2007). Moreover, imagery improves sport performance (Munroe-Chandler, Hall, Fishburne, Murphy, & Hall, 2012), strategies and tactics (Munroe-Chandler, Hall, Fishburne, & Shannon, 2005), sport competence (Catenacci, Harris, Langdon, Scott, & Czech, 2015), self-efficacy (Munroe-Chandler, Hall, & Fishburne, 2008; O, Munroe-Chandler, Hall, & Hall, 2014), and collective efficacy (Munroe-Chandler & Hall, 2004) all in young children (ages 7-17 years). Youth and adult athletes' use of imagery is similar in that they both use cognitive and motivational types of imagery (Hall et al., 2009). In fact, young athletes typically use MS imagery most and CG imagery the least (Hall et al., 2009). In a recent study with youth gymnasts (age 7-16 years), imagery use was found to be a significant predictor for gymnastics performance (Simonsmeier & Buecker, 2017).

Based on the extensive findings of passion's influences on multiple outcomes in sport and exercise and previous research findings of imagery use by children in

sport, the current study sought to examine the relationship between passion and imagery use in competitive youth gymnastics. It was hypothesized that the current sample would meet the passion criteria threshold of having means greater than three out of five (Vallerand, 2012). Upon meeting these criteria, it was hypothesized that obsessive passion would be more strongly related to imagery use than harmonious passion based on the high demands of competitive gymnastics.

## METHODS

A sample of youth athletes were recruited from multiple competitive gymnastics clubs across the province of Ontario, Canada. The participants included 245 (male,  $n = 10$ ; female,  $n = 235$ ) competitive gymnasts between the ages of 7-16 years. The total sample had a mean age of 9.13 years ( $SD = 1.90$ ) and a mean of 3.86 years ( $SD = 2.41$ ) experience in competitive gymnastics. The participants competed in woman's artistic gymnastics ( $n = 221$ ), men's artistic gymnastics ( $n = 7$ ), and trampoline and tumbling ( $n = 17$ ).

**Imagery.** The Sport Imagery Questionnaire for Children (SIQ-C; Hall et al., 2009) assesses the cognitive and motivational types of imagery first proposed by Paivio (1985) and later extended by Hall et al. (1998). The SIQ-C is a 21-item questionnaire measured on a five-point Likert scale anchored at 1 (*not at all*) and 5 (*very often*). For example, the statement "before doing a skill, I see myself doing it perfectly" assesses CS imagery and the statement "I see myself following the game plan or routine at competitions" assesses CG imagery. An example statement for MS imagery is, "I see myself as a champion", while "I imagine myself staying clam in competition" addresses MG-A imagery. Finally, the statement "I imagine myself being confident in competition" assesses MG-M imagery. The Cronbach's alpha internal consistency reliability scores for

each of the imagery subscales were between 0.64 and 0.83 respectively (CS = 0.83, CG = 0.64, MS = 0.76, MG-A = 0.81, MG-M = 0.74).

**Passion.** An adapted version of the Passion Scale (Vallerand et al., 2003), was used to measure passion in competitive youth gymnastics. The instrument was modified to reflect the context of gymnastics, and to ensure readability of the items were appropriate for a youth sample. The modified instrument included 15-items, with five items measuring harmonious passion, five items measuring obsessive passion, and five items measuring passion criteria.

Each item is measured on a five-point Likert scale anchored at 1 (*don't agree at all*) and 5 (*completely agree*). The statement "gymnastics still allows me to do other activities in my life" is a sample item for harmonious passion while the statement "if I could, I would only do gymnastics" is a sample item for obsessive passion. Finally, the statement "gymnastics is a part of who I am" is a sample item for the passion criteria. The Cronbach's alpha internal consistency reliability scores for the passion subscales were between 0.55 and 0.78 respectively (harmonious passion = 0.55, obsessive passion = 0.78, passion criteria = 0.77).

Upon receiving ethics clearance from the University's Research Ethics Board, contact was made to the gymnastics clubs through email. Consent was then obtained from gymnastics clubs and parents, while assent was obtained from all eligible athletes (i.e., 7-16 years, enrolled in a competitive gymnastics discipline, provincial gymnasts [levels 3-10]). The lead author travelled to each of the six clubs to collect the data. Prior to a training session, gymnasts were asked to complete general demographics questions including their age, gender, gymnastics club, gymnastics discipline, and their years of experience in competitive gymnastics. Next, participants were asked to complete two questionnaires; the SIQ-C (Hall et al.,

2009) to assess the frequency of imagery use, and the Passion Scale (Vallerand et al., 2003) modified for competitive youth gymnastics to assess their passion towards the sport of gymnastics specifically. The competitive gymnastics season begins in November and runs through to the end of May or the beginning of June, depending on the gymnast's level. Questionnaires were distributed and collected on the same day in the middle of the gymnasts' competitive season (January and February, 2019). Although we did not ask the athletes if they had participated in a competition this season, due to the timing of the data collection, it can be assumed that they all competed in at least one.

## RESULTS

Prior to carrying out the main analyses (i.e., assessing the relationship between passion and imagery), we wanted to ensure the sample of athletes were in fact passionate about their sport. As such, five items on the passion scale assess the criteria for someone to demonstrate passion. The mean scores from this subscale (passion criteria) would indicate as hypothesized, this was a passionate group of athletes ( $M = 4.66$  out of 5). Therefore, further analysis was warranted to test the relationship between passion and imagery in this sample. Table 1 presents the means, standard deviations, and Cronbach's alpha values of the study variables. Table 2 presents the Pearson Correlations between passion and imagery. Passion and imagery shared moderate to strong significant positive correlations. As expected, obsessive passion shared more salient relationships with imagery use than harmonious passion. Next, a series of multiple regression analyses were conducted to identify the variance accounted for in the passion-imagery relationship.

**Imagery.** The results of the multiple regression model depicting the associations between harmonious and obsessive passion

and imagery use are presented in Table 3. Overall, both passion subscales (harmonious and obsessive) were regressed with the five subscales of imagery and were significant. The regression model indicated that harmonious and obsessive passion were significantly and positively associated with CS imagery ( $R^2 = .15$ ; harmonious passion,  $\beta = .22$ ; obsessive passion,  $\beta = .24$ ) and CG imagery ( $R^2 = .18$ ; harmonious passion,  $\beta = .24$ ; obsessive passion,  $\beta = .27$ ). Similarly, the regression

models indicated that harmonious and obsessive passion were significantly and positively associated with MS imagery ( $R^2 = .23$ ; harmonious passion,  $\beta = .24$ ; obsessive passion,  $\beta = .33$ ), MG-A imagery ( $R^2 = .25$ ; harmonious passion,  $\beta = .29$ ; obsessive passion,  $\beta = .30$ ) and MG-M imagery ( $R^2 = .27$ ; harmonious passion,  $\beta = .39$ ; obsessive passion,  $\beta = .22$ ).

Table 1  
*Means, Standard Deviations, and Alphas for Demographic Information, Passion, and Imagery.*

Variable	Competitive Gymnastics		$\alpha$
	Mean	SD	
Age	9.13	1.90	
Years of Experience	3.86	2.41	
Passion			
PC	4.66	.46	.77
HP	4.10	.54	.55
OP	3.71	.82	.78
Imagery			
CS	3.72	.87	.83
CG	3.80	.68	.64
MS	3.78	.86	.76
MG-A	3.84	.87	.81
MG-M	3.96	.64	.74

*Note.* PC = Passion Criteria; HP = Harmonious Passion; OP = Obsessive Passion; CS = Cognitive Specific; CG = Cognitive General; MS = Motivational Specific; MG-A = Motivational General-Arousal; MG-M = Motivational General-Mastery; both measures scored on a 5-point scale with higher numbers reflective of greater passion and greater imagery use.

Table 2  
Correlations for Passion and Imagery.

	PC	HP	OP	CS	CG	MS	MG-A	MG-M
PC	1.00							
HP	.47*	1.00						
OP	.56*	.40*	1.00					
CS	.24*	.32*	.32*	1.00				
CG	.36*	.34*	.37*	.42*	1.00			
MS	.28*	.37*	.43*	.46*	.53*	1.00		
MG-A	.31*	.41*	.42*	.51*	.53*	.62*	1.00	
MG-M	.37*	.48*	.38*	.53*	.57*	.61*	.69*	1.00

Note: \*Correlation is significant at the 0.01 level (2-tailed). PC = Passion Criteria; HP = Harmonious Passion; OP = Obsessive Passion; CS = Cognitive Specific; CG = Cognitive General; MS = Motivational Specific; MG-A = Motivational General-Arousal; MG-M = Motivational General-Mastery.

Table 3  
Regression Analyses Between Harmonious and Obsessive and Passion.

Passion	Imagery	B	SE B	$\beta$	t
HP	CS	.36	.10	.22*	3.46
OP		.25	.07	.24*	3.64
HP	CG	.29	.08	.24*	3.69
OP		.23	.05	.27*	4.31
HP	MS	.37	.10	.24*	3.84
OP		.35	.07	.33*	5.44
HP	MG-A	.47	.10	.29*	4.83
OP		.32	.06	.30*	5.01
HP	MG-M	.46	.07	.39*	6.54
OP		.17	.05	.22*	3.73

Note: B, unstandardized beta (regression) coefficient; SE B, standard error of B;  $\beta$ , standardized beta (regression) coefficient; t, t-statistic short forms. PC = Passion Criteria; HP = Harmonious Passion; OP = Obsessive Passion; CS = Cognitive Specific; CG = Cognitive General; MS = Motivational Specific; MG-A = Motivational General-Arousal; MG-M = Motivational General-Mastery.  $p < 0.01^*$

## DISCUSSION

The aim of the current study was to explore the relationship between passion and imagery use in competitive youth gymnastics. It was hypothesized that the current sample would be passionate about gymnastics due to the substantial time commitment and level of engagement required. Additionally, it was hypothesized that obsessive passion would be more strongly related to imagery use than harmonious passion. Overall, results

indicated this was a highly passionate group of youth athletes and that both harmonious and obsessive passion shared significant positive relationships with all five types of imagery, with obsessive passion sharing the most salient relationship with four of the five types of imagery.

Harmonious passion was significantly and positively related to all five types of imagery. More specifically, harmonious passion had the strongest relationship with MG-M imagery, and in fact, had the

strongest relationship overall. Indicative of harmonious passion is having autonomous control over your activity engagement; for example, having a balance between their passion for gymnastics and daily life commitments (e.g., family, peers, school). This relationship with MG-M imagery may be explained by the nature of the MG-M items reflective of being in control (e.g., “I see myself being in control in tricky situations”). The caveat with the relationship between harmonious passion and MG-M imagery is that harmonious passion yielded a low Cronbach’s alpha value ( $\alpha = .55$ ) and as such this finding should be interpreted with caution. Upon further review of the harmonious passion items, we noticed the means for the item “gymnastics fits in well with other activities in my life” and “gymnastics still allows me to do other activities in my life” were much lower than the other three harmonious passion items. This seems to support the notion of the demanding time commitment required in competitive youth gymnastics (Cogan, 2006). Risks of early sport specialization have been well documented in previous literature which includes social isolation from family and peers, as well as limiting experiences in other sports and activities (Malina, 2010).

Obsessive passion had significant positive relationships with all five types of imagery and the most salient associations with four of the five types of imagery. More specifically, obsessive passion was most strongly related to MS imagery. Indicative of obsessive passion is having no control over activity engagement; for example, only focusing on their passion towards gymnastics and scheduling daily life commitments (e.g., school) around their passion towards gymnastics. Upon further inspection of the MS items on the SIQ-C, the nature of the items reflects an ego-oriented motivation (e.g., “I see myself as a champion”). This finding can be further explained by research with youth soccer, in which a relationship between obsessive passion and ego

oriented motivational climate was found (Ommundsen, Lemyre, Abrahamsen, & Roberts, 2013). In the context of competitive youth gymnastics, there are many opportunities for individual success, as gymnasts compete in multiple events within a single competition, several times throughout the season. For example, in any given gymnastics competition, there will be a champion on each of the four events (i.e., vault, bars, beam, floor), as well as an all-around champion in each category, based on age and level.

We were also interested in examining the types of imagery gymnasts use and it appears that gymnasts report using the motivational types of imagery more so than the cognitive types of imagery, which is supported in previous research with youth athletes (Hall et al., 2009) and adult athletes (Hall et al., 1998). Similarly, the cognitive types of imagery were less frequently reported, with CS being the least frequently reported type of imagery. However contrary to previous research, we observed the mean for CG imagery to be used more frequently in gymnasts when compared to other youth sport athletes (Hall et al., 2009). We reviewed the SIQ-C items again as a possible explanation for this finding. One summation is that in the sport of gymnastics, the word “routine” takes on a different meaning than in other sports. That is, when gymnasts refer to a routine, they are alluding to their actual sequence of performance (e.g., choreographed floor routine). Their routines are choreographed, and a specific set of skills must be performed in sequence or they are in danger of losing multiple points. For other sports, the term routine may refer to pre-competition and/or pre-shot routines as well as strategies and tactics (Munroe-Chandler, Giacobbi, Hall, & Weinberg, 2000). This may also help explain the low Cronbach’s alpha score for the CG subscale. This is consistent with previous research wherein the CG subscale has a pattern of yielding the lowest

reliability score of all the imagery subscales (Fish, Hall, & Cumming, 2004).

The findings of the present study also call into further examination of the manifestation of obsessive passion in high performing individuals and the resulting outcomes. The relationship between obsessive passion and maladaptive outcomes has been well established (Currant et al., 2015). However, the occasional adaptive outcomes that are yielded from obsessive passion for unique samples, such as high performers, cannot be disregarded. The current study demonstrated obsessive passion to be more strongly associated with imagery use, undoubtedly an adaptive outcome in high performance sport. Previous researchers have also uncovered such findings with obsessive passion and other adaptive outcomes in sport such as deliberate practice and performance (Vallerand et al., 2007, 2008), and team cohesion (Paradis et al., 2012). In the context of competitive sport, being obsessively passionate may be important for success, facilitating increased commitment, and ultimately, high performance outcomes (Paradis et al., 2012).

The present study is not without limitations. Due to the nature of the study (cross-sectional, correlational, one data time point) causation cannot be inferred. Although passion is accounting for some of the variance of imagery use, it is unclear what is accounting for the remainder of the variance. As a result, passion could also influence the use of other psychological skills (e.g., goal setting, self-talk). Likewise, other factors could influence the use of imagery (e.g., coaching, motivational climate, imagery ability).

The present study is the first to demonstrate the relationship between passion and imagery use in competitive youth sport. Previous researchers have shown that imagery use changes over the course of a competitive season (Munroe, Hall, Simms, & Weinberg, 1998). As such, future researchers should implement a

longitudinal design to measure the degree to which their passion or imagery use impacts one another. Imagery is a dynamic psychological skill used by athletes of all ages (Munroe-Chandler et al., 2007) and competitive levels (Hall, 2001). Future researchers should examine imagery along with passion in a larger population of athletes across sports and competitive levels. Further, researchers should also seek to assess the relationships of other commonly used psychological skills (e.g., goal setting, self-talk) with passion.

The present study's finding that harmonious and obsessive passion is positively associated with imagery use provides preliminary support of the importance of this mental skill in competitive youth gymnastics. By establishing that youth gymnasts demonstrate high levels of passion, this can inform future researchers to consider the adaptive (e.g., deliberate practice; Vallerand et al., 2007) and maladaptive (e.g., athlete burnout; Kent et al., 2018) outcomes from the time commitment and sustained engagement in competitive youth gymnastics.

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# THE REGULATORY INFLUENCE OF THE VISUAL SYSTEM: AN EXPLORATORY STUDY IN GYMNASTICS VAULTING

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*Original article*

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## **Abstract**

*Approach runs in order to maximize approach velocity are an inherent component in many sports. The goal of the study was to investigate the regulation of a complex motor task in gymnastics vaulting and the impact of the visual system within these processes. It was hypothesized that a visual perception-based strategy incorporating time-to-contact information derived from the variable tau is used to optimize the run-up in particular. Kinematic parameters of 10 gymnasts performing handsprings were examined. The analysis revealed that, on average, onset of visual control took place three steps prior to the hurdle. Linear regression showed that tau margin is dependent on the velocity of the approach run. The study supports the idea of a regulation of the run-up that is based on a visual strategy in which the influence of the vaulting table is crucial. The gymnasts were able to adapt the step length and duration respective to the movement velocity in order to facilitate an optimal transition of the run-up towards the take-off board and subsequent the vaulting table. In the process the influence of run-up velocity relating to the value of tau at the onset of visual control is of utmost importance.*

**Keywords:** *handspring, visual control, run-up, kinematic analysis.*

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## **INTRODUCTION**

Goal-directed run-ups are an inherent component in many sports. Every run-up has its own characteristic structure depending on the goal and the requirements of the intended motor skill (Jemni, 2018). Approach runs in order to maximize approach velocity to successfully perform a complex motor skill are typical for gymnastics vaulting (Bradshaw, 2004). For a well-performed and highly scored vault, gymnasts need to optimize each aspect of the vault, including the approach run as well as body posture and movement during subsequent phases of the vault (Bradshaw, 2004; Heinen, Jeraj, Thoeren, & Vinken, 2011; Heinen, Vinken, Jeraj, & Velentzas, 2013; Velickovic, Petkovic, & Petkovic, 2011).

The relevant information allowing athletes to guide and regulate their segment movements can be perceived through different sensory system, whereby the visual system can be considered as the most important (Vickers, 2007). Results from Heinen et al. (2011; 2013) highlight for instance that the perceived position of the springboard and vaulting table are relevant information sources that guide gymnasts' movement regulation during the approach run. Furthermore, Bradshaw (2004) and Meeuwsen and Magill (1987) had experienced gymnasts perform different vaults. It was found that a visual regulation strategy is used to adapt the last few steps prior to the hurdle and that movement regulation at an early stage in

conjunction with a fast approach run is likely to contribute to a well-performed and highly scored vault. Current empirical evidence thus clearly suggests that it is possible to regulate the approach run in order to perform a complex motor task, such as a handspring over the vaulting table in gymnastics. Nevertheless, the question still arises which role the visual system itself plays in the course of regulating the run-up prior to a complex motor skill in gymnastics vaulting.

There are several theoretical approaches that account for the process of movement regulation during whole-body movements. The theory of direct perception (Gibson, 1986) treats athletes as open biophysical systems, where a constant interaction between the environment and sportsperson can be seen as the key criterion to movement regulation (Raab, Oliveira & Heinen, 2009). In gymnastics vaulting, visually guided movement regulation is evidentially utilized to perform complex motor tasks (Bradshaw & Sparrow, 2001; Bradshaw, 2004; Heinen et al., 2011; Heinen et al., 2013; Lee, Lishman, & Thomson, 1982). Visual perception is an active process in which information of the surrounding environment is interpreted using light. This "optic array" (Gibson, 1986, p. 73) has a defined structure depending on the place of observation. Hence, the optic array is constantly changing while the gymnast is moving, whereby the invariants are unchanging, visually perceptible sources such as the vaulting table (Gibson, 1986). Thus, perceptual information is thought to guide motor tasks, without an immediate necessity of cognitive interpretation (Raab et al. 2009).

During the approach towards an obstacle the retinal image undergoes a dilation. The center of this "optical flow" (Gibson, 1986, p. 123) is considered to be an invariant used as a reference in goal-directed motor tasks (Magill, 1989; Gibson, 1986). In the individual reference frame consisting of the gymnast and the

environment, only information obtained from the invariants and the changes in the optical flow field is relevant for visually based movement regulation (Araújo, Davids, & Hristovski, 2006; Gibson, 1986; Williams, Davids, & Williams, 1999). Based on Gibson's theory of direct perception, Lee (1976) as well as Lee and Kalmus (1980) argued that relevant information can be obtained directly from the optic flow field. Both the ecological stimulus and the body movement exhibit spatiotemporal components. Following the authors' argumentation, it can be stated that in the course of the run-up absolute variables such as velocity, size of the obstacle or other physical quantities are unlikely to be of importance for visually based regulation. Instead, body scaled visual information is thought to allocate the necessary information (Lee, 1998). The corresponding variable which incorporates the concept of how a target-directed action can be controlled based on the perception-action-relationship of the ecological approach was denoted as *tau* ( $\tau$ ) by Lee (1976). *Tau* is comprised of the spatiotemporal component and it specifies the time-to-contact ( $T_c$ ), the time until a collision with an object would occur. Following Gibson's ideas, *tau* depicts a "formless invariant" (Lee, 1998, p. 225).

A constant flow of velocity vectors originating from the reflected ambient light is the basis for determining time-to-contact information. Consequently, it becomes apparent that information regarding distance can be obtained directly from the retinal image projected by the obstacle onto the gymnast (Tresilian, 1991; Williams et al., 1999). By the time *tau* reaches a threshold value the gymnast is able to anticipate the following path of motions, facilitating the initiation of the required adjustments to reach the intended movement goal. This threshold value was denominated as "tau margin" (Lee & Young, 1985, p. 3). It has been presented in detail that the time-to-contact can be determined by two different forms of *tau*.

On the one hand, there is “global tau” (Tresilian, 1991, p. 866), which is a variable that takes the entirety of the optical flow field into account. Global tau is defined as the ratio between the center of the optical flow field undergoing a dilation in relation to the distance of an obstacle  $r$  (respectively  $Z$ ) and the sportsperson’s velocity  $\dot{r}$  (respectively  $\dot{Z}$ ). On the other hand, there is “local tau” (Tresilian, 1991, p. 866), which can be determined as the ratio of two points on the surface of the obstacle undergoing a dilation. Based on the last-mentioned equation it is possible to determine how tau changes in the course of the sportsperson’s movement.

Lee’s theory, however, exhibits several points of criticism. It can be stated that the application spectrum is limited to movements with constant velocity and direct collision by the theory itself (Williams et al., 1999). Nevertheless, studies by Lee and Reddish (1981) and Lee et al. (1982) underline the possibility to control a motor task with non-constant velocity based on the time-to-contact information specified by tau. Wann and Tresilian expatiated upon the mathematical derivation and the deficiency of tau to specify the  $T_c$  information. Assuming direct collisions as the core requirement excludes both points of criticism mentioned in this study. For more detailed analysis see Tresilian (1990; 1991; 1994; 1999, 2005) and Wann (1996). Lee et al. (1982) analyzed the run-up of three international long jumpers in order to answer the question of how the acceleration in the “approach” and “zeroing in phase” (p. 455) towards the take-off board is regulated. It was found that during the last five steps the athletes were able to decrease the standard deviation to a maximum of 5 cm, which enabled them to hit the board with precision. Similar findings from Hay (1988), Berg, Wade und Greer (1994), Scott, Li and Davids (1997) supported the conclusion that the run-up can be advantageously regulated by utilizing

visual information. In gymnastics vaulting the afore-cited studies of Meeuwssen und Magill (1987) and Bradshaw (2004) underline the advantage of regulating the run-up through a visually based regulation strategy. In both studies the obstacle was a vaulting horse, which has been replaced in 2001 by the vaulting table. In conclusion the studies provide empirical evidence for the theory of ecological perception which assumes that complex motor tasks are regulated with an individual body-scaled reference frame.

However, the utilization of tau can only be derived, which is why there is no consistent evidence that empirically substantiates the theory of movement regulation by means of the optical variable tau (see also Williams et al., 1999). Moreover, the influence of the vaulting table with its specific three-dimensional expansion as well as the rate of change of tau and its derivation  $\dot{\tau}$  has not been examined. Taking the empirical and theoretical groundwork into account it was predicted that gymnasts use a visual strategy to regulate their run-up prior to a vaulting skill through the time-to-contact information derived from Lee’s variable tau. To examine this prediction, gymnasts with different levels of expertise were asked to perform a handspring on vault during which the kinematic parameters of the run-up were measured. It was expected that the standard deviation of the steps prior to the hurdle should reduce considerably in compliance with the findings of Bradshaw (2004), Meeuwssen and Magill (1987) as well as Velickovic et al. (2011).

## METHODS

$N = 10$  participants took part in this study ( $n = 5$  men and  $n = 5$  women). Participants were between 22 and 30 years of age (mean  $\pm$  SD:  $26.9 \pm 3.18$  years). Being able to perform a handspring in compliance with the technical guidelines was the key criterion for the recruitment of

the participants. In contrast to novices, a group with this level of expertise display a better overall performance regarding for example the use of cognitive strategies as well as their technical and physical preconditions (Chi, 2006). Therefore, the participating mid-range gymnasts can be considered as a group with more advanced skills and capabilities than novices, particularly regarding an enhanced ability to use the visual system efficiently when performing the experimental task. Prior to the study, all participants were informed about its purpose as well as the procedure and gave their written informed consent. The study was carried out in line with the guidelines of the local ethics committee.

The experimental task for the gymnasts was to perform handsprings on vault. Each participant was asked to perform three trials, leading to a total of 30 handsprings. The vaulting table was adjusted to a height of 1.25 m for women and 1.35 m for men. In compliance with the guidelines of the FIG the run-up had a maximum length of 25 m (Fédération Internationale de Gymnastique [FIG], 2017). The handspring can be subdivided into three functional phases, namely the preparation phase, the main phase, and the final phase (Magill, 1989). The preparation phase consists of the first step, a short and powerful sprint-run, the last step, as well as a hurdle movement (Arkaev & Suchilin, 2004; Bradshaw, Hume, Calton & Aisbett, 2009). The approach-run is a cyclic movement with the aim of achieving task-dependent velocity prior to the vaulting motion (Prassas, Kwon & Sands, 2006). At the end of the hurdle, the gymnast places his or her feet onto the springboard and slightly in front of the upper body. The joints of the ankles, knees and hips are flexed and fixated in order to prepare the takeoff and the first flight phase. The kinetic energy resulting from the run-up is used to optimize the subsequent main phase (Bradshaw, 2004; Schärer, Lehmann, Naundorf, Taube & Hübner, 2019).

The main phase of the handspring can be subdivided into five subphases: the takeoff, the first flight phase, the repulsion phase, the second flight phase and the landing phase. By pushing off the board the gymnast enters the first flight phase, moving the hands towards the vaulting table which initiates a rotation around the transversal axis of the body. With tension in the whole body, vertical and horizontal velocity are modified as a consequence of the repulsion, regulating the angular momentum of the handspring. The subsequent second flight phase with controlled angular momentum leads to the last and final phase of landing in an upright position (Farana & Vaverka, 2012; Hedbávný & Kalichová, 2015).

To determine the approach run and handspring kinematics, an optical movement analysis system was used. The handsprings were recorded using a USB 3.0 video camera type (Basler acA 1920-155) with a spatial resolution of 1920x1200 pixels and a sampling rate of 100 Hz (temporal error:  $\pm 0.01$  s, spatial error:  $\pm 8$  mm). The camera was placed orthogonally to the running track, springboard and vaulting table, capturing 13 m of the approach run as well as the backmost edge of the vaulting table. The adjustment was made in order to ensure comparability between the different lengths of the participants' run-ups. In this manner the approach run, last step and hurdle, takeoff, first flight phase, and the repulsion phase were recorded (Figure 1). Gymnasts were marked with white adhesive strips at the temple and the hip. The time-course of the velocity and acceleration of the marker as well as the coordinates of the feet were analyzed by adding the video data to the video analysis and modeling tool Tracker of the Open Source Physics project. Each video was analyzed consecutively in order to obtain the x- and y-coordinates of the aforementioned markers. The onset of visual strategy use for movement regulation was marked by a peak standard

deviation of the footfall position. A subsequent systematically decreasing standard deviation was a distinctive feature (see also Bradshaw, 2004; Lee et al., 1982).

The study was conducted in three phases. In the first phase, the gymnast arrived at the gym and the aim and the procedure of the study were explained. After completing the informed consent form, the gymnast could warm up individually for 15 minutes. In order to familiarize and prepare the athlete's motor system in an optimal way for the experimental task, the gymnast was allowed to perform 3 handspring trials after the warm-up phase. Subsequently, adhesive strips were attached to the gymnast's temple and hip. In the second phase, the gymnast was asked to perform three handsprings. Between the trials, the gymnast was allowed to rest individually to guarantee each motor task was performed as precisely as possible. Each vault was videotaped as described above, including the run-up, takeoff, first flight phase and repulsion phase. In the third phase of this study, after having performed three handsprings, the gymnast was debriefed.

For this study, a significance criterion  $\alpha = 0.05$  was defined a priori. At the beginning, the distance to the vaulting table and the duration regarding the use of visual movement regulation were computed. Based on the collected data it was investigated whether there is a relation between the distance to the vaulting table or the time and the initiating use of a visual strategy utilizing linear regressions. Tau was computed with equation 1 and its values in the course of the gymnasts' movement were investigated:

$$\tau_2^{(1)} = \frac{d}{v} = -\frac{z}{z'} \quad (\text{equation 1})$$

By differentiating equation 1 with respect to time (Bardy & Warren, 1997), it is possible to determine the change of tau  $\dot{\tau}$  during the run-up. Moreover the possibility

to control a motor task on its basis was examined:

$$\dot{\tau} + 1 = \frac{z''}{z'} \quad (\text{equation 2})$$

Equation 2 highlights that a value of  $\dot{\tau} > 1$  during the approach implies acceleration, whereas values of  $\dot{\tau} = 1$  imply movements with constant velocity and a  $\dot{\tau}$  between 0.5 and 1 will lead to a controlled collision. The values of  $\dot{\tau}$  were computed between each step.

## RESULTS

First, the analysis showed that in four cases onset of visual control took place three steps prior to the hurdle, with an average distance of 7.05 m (SD = 0.74), an average velocity of 6.5 m/s (SD = 0.09), and an average duration of 0.83 s (SD = 0.06). From the standard deviation it can be derived that the start of visual control with reference to distance and duration is similar regardless of the total number of steps. The data of two gymnasts indicated visual strategy onset four steps prior to the hurdle leading consequently to different values for distance and duration, whereas the gymnasts' velocity accords with the afore-mentioned valuation. Linear regressions yielded a significant correlation neither between visual regulation onset and velocity ( $r = .15, p = .78$ ) nor between distance to the vaulting table at the onset of visual regulation and velocity ( $r = .52, p = .29$ ). The analysis of data of four participants added up to divergent findings which did not correspond to the hypothesized pattern.

Second, analysis revealed the onset of visually guided movement regulation, which started with the antepenultimate step to the hurdle exhibited a tau of 1.05 (SD = 0.07). The values of tau marking the onset of visual control, more specifically tau margin, showed little deviation. Analogous results followed from the data analysis of the gymnasts in whose cases the onset of visual control occurred four steps prior to

the hurdle ( $M_{\tau} = 1.36$ ). In this case, tau margin exhibited a higher value due to the temporal and spatial differences respective to the beginning of visual regulation (see Table 1). In addition, the values of tau margin diverged very little as well ( $SD = 0.08$ ). Linear regression revealed that tau margin was correlated with gymnasts' velocity of the approach run ( $r = .81, p = .048$ ). Visual regulation of the run-up was

initiated when tau reached an average value of 1.16. The tau-theory is based on the hypothesis of tau providing information about time-to-contact that is utilized for instance in movement regulation. It was shown that with a decreasing distance to the vaulting table and an increasing velocity up to the last step, the variable declined.

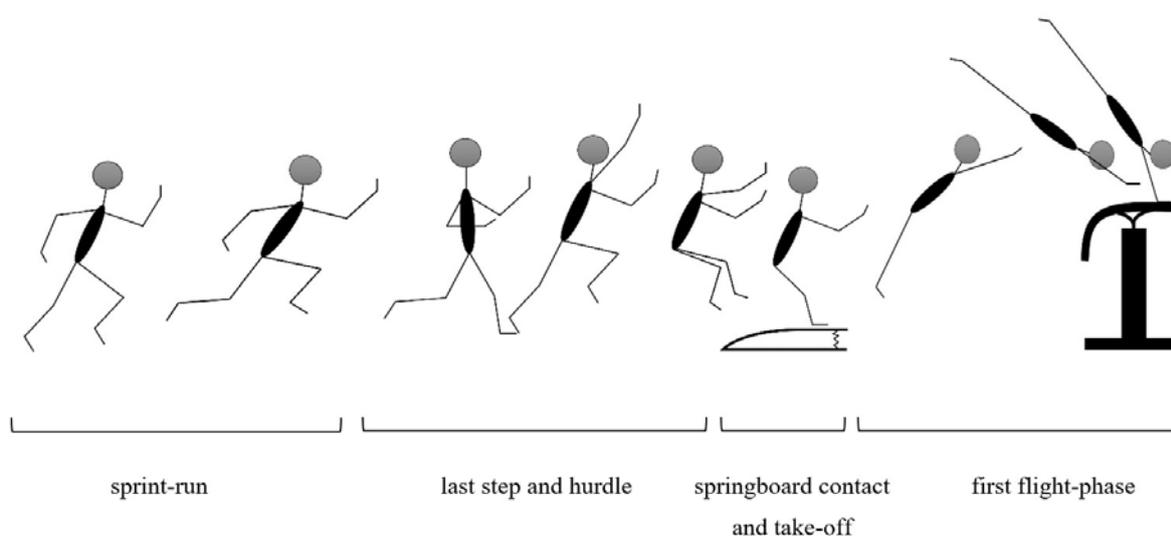


Figure 1. Stick-figure sequence of the video-taped phases of the motor task (handspring on vault).

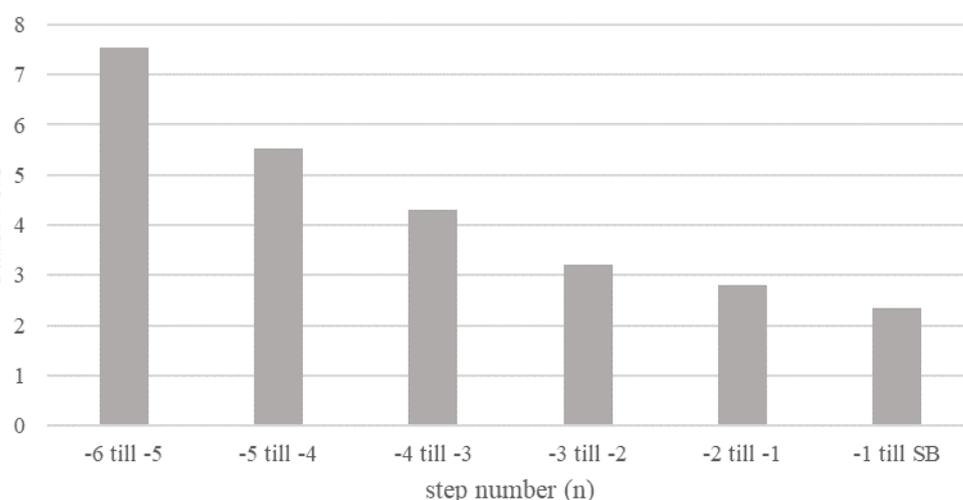


Figure 2. Mean values of  $\tau$  as well as its changes during the steps in the approach-runs, for participants with 6 recorded steps.

Table 1  
Values of tau for visual regulation onset.

Participant	Step number (n)	Tau	
		$M_x$	$s_x$
3	-3	-1.00	0.02
4	-3	-1.02	0.02
6	-4	-1.43	0.01
8	-3	-1.16	0.02
9	-4	-1.28	0.10
10	-3	-1.00	0.02

Table 2  
Values of  $\dot{\tau}$  for the steps referring to participants with 6 recorded steps prior to the hurdle (Note: SB = contact with springboard).

Step	Participant				$\dot{\tau}$	
	2	4	8	9	$M_x$	$s_x$
-6 till -5	5.99	8.67	7.17	8.33	7.54	1.05
-5 till -4	4.55	5.98	5.71	5.92	5.54	0.58
-4 till -3	3.47	4.76	4.51	4.50	4.31	0.50
-3 till -2	2.91	3.25	3.19	3.54	3.22	0.22
-2 till -1	2.55	2.70	2.92	3.04	2.80	0.19
-1 till SB	2.35	2.03	2.64	2.34	2.34	0.22

Table 3  
Values of  $\dot{\tau}$  for visual control strategy onset.

Participant	Total number of steps	Visual strategy onset at step n	$\dot{\tau}$	
			$M_x$	$s_x$
3 and 10	7	-3	2.48	0.00
6 and 9	6 or 7	-4	4.45	0.05
4 and 8	6	-3	3.22	0.03

Third, tau's rate of change over time  $\dot{\tau}$  is presented for each step in Table 2 and 3. The starting values are individually different due to different velocity and acceleration development. Analysis of the mean value of  $\dot{\tau}$  for the gymnasts with 6 recorded steps until the hurdle revealed a systematic decrease of this informational variable with decreasing distance to the obstacle (see figure 2). Moreover, the standard deviation of the mean values of  $\dot{\tau}$  exhibited a systematic diminution in the

course of the run-up, which leads to a mean variation from the antepenultimate step until the hurdle and constant values regarding the change of tau over time (see Table 2). A similar development could be found for gymnasts with 7 recorded steps prior to the hurdle. Until step -1 the decrease occurs analogously, which also holds true for the standard deviations of the corresponding mean values. Accordingly, the mean value of  $\dot{\tau}$  between step -2 and -1 exhibits a standard deviation of 0.26. Hence it can be stated that the mean values of the penultimate step in

both groups represent the aggregate data of the corresponding step in an adequate fashion. In contrast, the computed values of  $\tau$  for the last step and hurdle in the second group do not correspond to the displayed pattern. In fact, a renewed increase of  $\tau$  is evident. One attempted explanation could be to assume the data of gymnasts 1 and 7 as anomalous. Both recorded run-ups do not accord with the pattern. Regarding participant 7, it could be hypothesized that the changing number of steps in the different attempts are the reason for the anomaly. In attempt 1, 6 steps could be recorded, in contrast to 7 steps in the following two attempts. In the case of athlete 1, the computed values of  $\tau$  for the last step are higher than the value of  $\tau$  for the first step, which is conspicuous, considering the other gymnasts' data record (see Table 3). For the moment of hitting the springboard, an average velocity of 5.67 m/s as well as a value of  $\tau = 2.28$  (SD = 0.71) for the change of tau over time was computed for all gymnasts. Furthermore, it became apparent that the values of  $\tau$  for the onset of visually controlled motor execution differed marginally between the athletes (see table 4). It is important to note that the data analysis and interpretation is carried out by comparing the values of  $\tau$  referring to gymnasts with the same total number of recorded steps as well as the same step number at the beginning use of a visual control strategy. Perception-based movement regulation starting with the fourth from last step ( $n = - 4$ ) yielded similar values for  $\tau$ .

## DISCUSSION

The goal of the study was to investigate the regulation of complex motor tasks involved in gymnastics vaulting and the impact of the visual system within these processes. It was hypothesized that a visual perception-based strategy that incorporates time-to-contact information derived from Lee's

variable tau is used to optimize each aspect of the run-up. Therefore, it was speculated that the data analysis would provide evidence for the application of a visual strategy and that the standard deviation of the steps prior to the hurdle would thus reduce considerably. The study was able to produce proof for the regulation of the run-up prior to a gymnastics vault based on a visual strategy in which the influence of the vaulting table is crucial. It seems possible to guide target-directed movements by visually perceiving the time-to-contact information specified through the variable tau. When tau reached a threshold value ( $\tau_{step - 3} = 1.05$ ;  $\tau_{step - 4} = 1.36$ ), a considerable decrease of the standard deviation could be validated, starting with the third and fourth to last step, respectively. The differing results from four participants relative to the pattern of a decreasing standard deviation during the run-up indicate that the findings of the study should be verified through further research with a larger sample. It can be reasoned that this variation may emerge from the partial videotaped run-up. Tau's rate of change over time did also exhibit a systematic decrease resulting in a well-executed handspring, in which a value of  $\tau = 2.28$  is considered to be advantageous.

Taking the results into consideration, the measured distance at the onset of visual control (7.06 m) is similar to the findings of Bradshaw and Sparrow (2001), who stated a distance of 4.91 m. The differences arise from the reference point of the measurement. Bradshaw and Sparrow measured the distance to the take-off board, whereas in this study the distance to the vaulting table was measured. Taking into account the length of the take-off board, as specified by the technical committee of the FIG (FIG, 2017), as well as the distance from the take-off board to the vaulting table, which was set individually by the gymnasts, led to similar results. Bradshaw (2004) was able to provide analogous results in

gymnastics vaulting. Analyzing Yurchenko vaults, the author determined that 7.83 m of the run-up were regulated on the basis of visual perception. Disparities regarding run-up velocity and the following duration of the visual regulation strategy in this study result from the unique kinematic structure of Yurchenko vaults (Atiković & Smajlović, 2011; Naundorf, Brehmer, Knoll & Bronst, 2008).

Furthermore, the presented study provides evidence for the use of a visual strategy to regulate goal-directed movements, as Bradshaw (2004) was able to establish for other vaulting groups. In spite of increasing velocity, the gymnasts were able to adapt the steps' length and in order to facilitate an optimal transition of the run-up towards the take-off board and the vaulting table. In the process, the influence of run-up velocity relating to the value of tau at the onset of visual control is of utmost importance. This dependent relationship was established by Bradshaw and Sparrow (2001) in a previous study. An early onset of visually controlled movement leads to a longer and particularly more effectively controlled and adapted run-up. It was previously verified by Bradshaw (2004) that a longer duration of regulation based on visual perception leads to a vault that is performed better and scored higher. In consequence, the challenge for athletes and especially for coaches is to find a balance in the field of technical training between high run-up velocities and maximized duration of visual determined run-up regulation. Bradshaw (2004) summarized the advantages arising from the utilization of a visual strategy in a concise fashion. Alterations and varying foot placements in the course of the run-up were caused by intrinsic and extrinsic factors. Signs of fatigue, improved performance prerequisites or a lack in concentration due to inner restlessness are examples of intrinsic factors. In contrast, changes in the surrounding conditions such as different light or apparatus conditions at

competitions as compared to the home gym, as well as the audience, represent extrinsic factors.

The irregularities regarding 5 of the participants could result from the limited recording zone. It is unproven that a systematic reduction of the standard deviation marking the onset of the visual regulation strategy could not occur earlier in the course of the run-up. Therefore, another study is required to investigate the pattern of the run-up beginning with the first step. The presented study showed that the onset of visual control is not influenced by the parameters time or distance to the vaulting table. Instead, a value of tau margin was established which influences the regulation of the run-up. In contrast to the findings of Bradshaw and Sparrow (2001), the results did not reveal two phases within the run-up. On the one hand, only a section of the vault run-up was recorded. The gymnast's velocity increases towards the vaulting table, whereby no acceleration phase can be separated. Hence the developing of tau's rate of change over time did not exhibit a minimum. On the other hand, the experimental task was of a different nature. Both studies incorporated the crossing of a take-off board. However, the vaulting table and the handspring are additional elements in the current study, which resulted in a modified experimental task. Based on their results, Bradshaw and Sparrow (2001, p. 425) ultimately came to a similar conclusion: "Target and obstacle characteristics were shown to constrain step length regulation for the whole approach, with the number of defining boundaries and other qualitative differences being the main circumstances underlying this". The hypothesis by Lee et al. (1992) that a value of  $\tau > 1$  corresponds to an accelerating movement was confirmed. An increasing velocity in conjunction with the approach towards the vaulting table was associated with a systematic reduction and adaption of  $\tau$  leading to an advantageously timed movement, whereby an optimized hurdle

and first flight phase is ensured. Due to similar velocities and distances to the vaulting table at the onset of visual control, the values of  $\tau$  are comparable as well. Whether or not this applies to a wider range of performance level cannot be resolved sufficiently. In conclusion, the study could not definitively establish a regulation based solely upon tau. It is necessary to investigate the potential influence of other visual parameters such as the size of the obstacle, retinal velocity and others. Following the dynamic systems approach to action and perception that is based on the deliberations of Turvey (1990) and Kelso and Haken (1995), learning is associated with and notably requires the self-organization of a subject in order to stimulate learning and optimization processes. In the course of the acquisition and the retention of a technique, individual variations are always to be found. This is due to the fact that there is only a mean probability for an athlete to replicate the structure of a movement accurately. Following this argument, it becomes clear that it is necessary to support the athlete's ability to adapt to changing surrounding conditions. Taking this into account, Schöllhorn, Hegen and Davids (2012) argued in favor of a theory of differential learning, in which the form of teaching and the learning process can be adjusted individually in consideration of the personal abilities and needs of the athlete. These Processes and adjustments are undertaken in order to enable the athletes to perform a general technique. During a gymnastics competition the movements are graded based on criteria referring to a general technique and execution. In conclusion, this deductively guided inductive learning process can be an effective way to enhance gymnastics training. This can be derived from the results of the study that visual regulation is individually different. In addition, there are further practical consequences that can be drawn from the results of the study.

The visual regulation strategy to adapt and adjust the approach run depends on the height and width of the obstacle (Meeuwssen & Magill, 1987). Regarding the acquisition of the unique approach run in gymnastics vaulting, different parameters have to be variegated. First, the length of the run-up track should be changed constantly so the gymnasts are forced to adapt their movements to the new condition without reducing the quality of execution. Second, considering the gymnasts' age and abilities, the learning process of a handspring should begin with fewer steps and a reduced approach velocity. Consecutively, the variation of the length of the run-up is introduced so that the gymnasts are able to define their ideal run-up distance. Similar conclusions have been drawn by Bradshaw and Sparrow (2001) as well as Bradshaw (2004). Furthermore, the distance from the take-off board to the vaulting table can be modified (Heinen et al., 2011). The authors argue that a training which exposes the learner to different conditions by modifying the approach run or take-off board distance can convey different movement experiences and variable disposal referring to the general technique. This position corresponds to the findings in the current study. The use of a visual strategy could be improved by marking spots in the course of the run-up, for example at the take-off board or vaulting table (see for instance Heinen, Vinken, & Fink, 2011). The dimensions of the object that is to be vaulted or used for further movements is highly important for the regulation of the run-up (Bradshaw & Sparrow, 2001). Taking this into account, Bradshaw (2004) reasoned that the inclusion of different targets into training is a basic necessity. The results presented by the author indicate that a visually regulated run-up that begins at an early stage as well as a wide range of movement experiences and visual strategies contribute to a better vaulting performance in changing surrounding conditions. As

previously described, the regulation is based upon the specific obstacle which is why it should be examined which effect such training methods have on the gymnasts' vaulting performance and abilities.

## CONCLUSION

We conclude that the run-up in gymnastics vaulting is subject to a visual strategy with which athletes can adapt the approach run as well as the hurdle prior to a handspring on vault advantageously by using time-to-contact information specified by the variable  $\tau$ . However, we add that future studies should explore whether these values of  $\tau$  differ between novice and top-ranking gymnasts and whether differences can be found regarding other vaulting groups (e.g., Tsukahara vaults). Furthermore, it should be investigated whether there is a correlation or relationship of dependency between the values of  $\tau$  and  $\tau^*$  and the score of the judges and the level of execution. Beyond that, there is a lack of empirical evidence for possible transfer effects on the onset and duration of visual regulation resulting from the use of different obstacles and colored markings. Relevant insights could provide opportunities of adjusting training programs in order to enhance the acquisition and retention of handspring and gymnastics vaulting performances in general.

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# ASSOCIATION BETWEEN MUSCLES' CONTRACTILE PROPERTIES AND JUMPING PERFORMANCE IN GYMNASTS

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*Original article*

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## **Abstract**

*This study examined the association between muscles' contractile properties and jumping skill performance in gymnasts. Thirty-nine internationally experienced female (56%) and male (44%) gymnasts participated in the study. Radial displacement and contraction time of the biceps femoris, rectus femoris, vastus lateralis, vastus medialis, and erector spinae were collected to assess muscles' contractile characteristics using tensiomyography (TMG). Additionally, peak power, jump height, vertical take-off velocity, and vertical peak force in squat jump, countermovement jump, and drop jump were recorded. The TMG parameters did not predict jumping performance in our sample of female and male gymnasts. Associations between TMG parameters and jumping performance are discussed in the article.*

**Keywords:** *artistic gymnastics, countermovement jump, squat jump, drop jump, explosive power.*

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## **INTRODUCTION**

The purpose of a jump in artistic gymnastics is to perform turns, twists, and/or to reach a desired posture in the air. Exhibition of strength, power, flexibility, and spatial awareness is needed to perform jumps, leaps, hops, and acrobatic skills with control and amplitude, allowing errorless execution. Performance of ballistic movements, such as jumps, leaps, hops, or sprints is clearly determined by high levels of force, power, and velocity (Cormie, McGuigan, & Newton, 2011a, 2011b; Cronin & Sleivert, 2005). Explosive power is the main determinant of performance (i.e., height of a jump) in such activities because it determines velocity at release or take-off. The take-off velocity, however, is determined by the force the muscles generate against the floor and the time during which the forces are

applied (Newton & Kraemer, 1994). Production of peak power or the highest power value achieved during a jump, peak velocity, peak force, and jump height are the most important variables to describe leg muscle explosive function for athletes (Riggs & Sheppard, 2009; Young, Cormack, & Crichton, 2011).

One of the conventional tests used to assess explosive power is the vertical jump. It is usually conducted in three variations: (a) squat jump (SJ), (b) countermovement jump (CMJ), and (c) drop jump (DJ). All of aforementioned jump tests are reliable and valid measures for the estimation of explosive power of the lower limbs (Arteaga, Dorado, Chavarren, & Calbet, 2000; Markovic, Dizdar, Jukic, & Cardinale, 2004; Viitasalo, 1988) and are used as 'gold

standard' tests in scholarly literature. Additionally, the characteristics of the CMJ with arm swing were found to be similar to standing back somersaults performed on the spot (Mkaouer, Jemni, Amara, Chaabèn, & Tabka, 2012).

In order to enhance power production in jumping, certain properties of involved muscles are needed. For example, one of the factors that significantly influences power performance in jumping is muscle stiffness (Chelly & Denis, 2003; Watsford, Ditroilo, Fernández-Peña, D'Amen, & Lucertini, 2010). To maximize vertical take-off velocity and mean mechanical power, the proper muscle stiffness has to be employed (Arampatzis, Schade, Walsh, & Brüggemann, 2001). Tensiomyography (TMG) is one of the reliable and valid methods used to measure contractile properties of the muscle. It can be used as an injury diagnostic tool or as a tool for monitoring training effectiveness. Radial displacement (Dm) of a given muscle measured with TMG is thought to reflect the muscle contractile force and muscle stiffness (Dahmane, Djordjevič, Šimunič, & Valenčič, 2005; García-Manso et al., 2012, 2011; Križaj, Šimunič, & Žagar, 2008; Pišot et al., 2008). Additionally, TMG can also measure the duration of the muscle contraction (Tc) which can be associated with higher contraction velocities. It has been proven that shorter Tc correlates with running speed for 20m flying sprint (Dahmane, Djordjevič, & Smerdu, 2006). Consequently, it is plausible that Dm and Tc could be indirectly associated with performance in motor tasks involving a stretch-shortening cycle (i.e., jumping skills), during which power production is essential. Lower Dm which corresponds to a greater muscle stiffness and lower Tc which corresponds to higher contraction velocities could indicate superior jumping performance.

To our knowledge there has been only one study conducted that investigated the association between TMG parameters and performance in power-related motor tasks.

Gil et al. (2015) conducted a study on 20 elite soccer players which investigated the association between TMG parameters (Dm and Tc) and jumping and sprinting abilities. They found the following significant associations between TMG parameters and parameters from countermovement jump, drop jump tests, and 25 m maximal-effort sprints: (a) a moderate negative association between Dm of the biceps femoris and contact time, (b) a moderate negative association between Dm of the rectus femoris and contact time, and (c) a moderate association between Dm of the biceps femoris and reactive strength index. The lack of associations was discussed as a deficiency of TMG in measuring coordinative and control parameters that are also involved in complex jumping tasks. In contrast to jumping and sprinting tasks, where several muscles are involved in movement, some muscles also transfer power between joints; the TMG measures a muscle in an isolated environment. Dm and Tc seem to imply higher muscle stiffness and could be considered a valid measure for stretch-shortening cycle efficiency, but in the aforementioned study they lack the ability to predict jumping performance due to the study's insensitivity to the task complexity.

Whether associations between TMG parameters and jumping performance would be different when (a) measuring athletes from other sports, (b) measuring TMG parameters on other muscles involved in jumping than the rectus and biceps femoris, and (c) using other variables for measuring jumping performance, are questions which remain unanswered. The purpose of the present study is to investigate the association between TMG parameters and jumping skill performance in gymnasts.

Stretch-shortening cycle efficiency is very important for performance in soccer and gymnastics, and enables athletes to jump high and in a required direction. However, jumping technique between soccer players and gymnasts differs significantly, because

they train and compete in different environments. Soccer is played on a soccer pitch with little elasticity and gymnasts perform on the gymnastics floor, vault, balance beam, etc., which have good elasticity; this probably affects the jumping technique. It has been proven before that the elasticity of different training surfaces could lead to diverse muscle responses (Rojas-Barrionuevo, Vernetta-Santana, Alvariñas-Villaverde, & López-Bedoya, 2017), indicating different muscle adaptations to different training characteristics in the long term. Gymnasts' jumping is characterized by an extremely fast force development because of the time constraints of the tumbling take-offs that take less than 150 ms (Marina, Jemni, & Rodríguez, 2013; Marina, Jemni, Rodríguez, & Jimenez, 2012). A soccer game is played for 90 minutes during which time players run as far as 15 km. A gymnastics competition lasts for approximately 120 minutes with the longest routine for women/men lasting 90/70 seconds (limited by the Code of Points (Federation Internationale De Gymnastique, 2017a, 2017b)) in which gymnasts perform up to 20 jumping gymnastics skills. These skills are technically determined by gymnastics rules and are very demanding in their complexity. The execution of jumping skills is not predetermined in soccer, but they are demanding mostly due to the unpredictable environment that a soccer match creates. It might be that TMG parameters would be able to predict jumping performance in gymnasts who use different jumping techniques in comparison with soccer players. It is hypothesized that TMG parameters are positively associated with parameters indicating leg muscle explosive function during jumping skills.

## METHODS

Thirty-nine gymnasts, who are all internationally experienced competitors,

participated in the study. The sample comprised 22 (56%) female gymnasts aged  $15.76 \pm 3.39$  years (height:  $159.14 \pm 5.21$  cm; weight:  $49.00 \pm 5.94$  kg) and 17 (44%) male gymnasts aged  $17.40 \pm 6.08$  years (height:  $158.35 \pm 13.03$  cm; weight:  $53.29 \pm 15.02$  kg). The local ethics committee approved the procedure of the study. All participants were informed about the aim of the study and signed their informed consent prior to the study.

The testing procedure consisted of (a) a TMG measurement protocol and (b) jump tests. Participants performed familiarization sessions with all testing procedures one day before attending a testing session which was used for the analysis.

**TMG measurement protocol:** Radial displacement (Dm) and contraction time (Tc) of the biceps femoris (BF), rectus femoris (RF), vastus lateralis (VL), vastus medialis (VM), and erector spinae (ES) muscles were collected using a TMG device (TMG Measurement System, TMG-BMC Ltd., Ljubljana, Slovenia). The validity of the TMG parameters has been proven before (Ditroilo, Smith, Fairweather, & Hunter, 2013; Križaj et al., 2008; Martín-Rodríguez, Loturco, Hunter, Rodríguez-Ruiz, & Munguia-Izquierdo, 2017; Ruiz et al., 2012; Tous-Fajardo et al., 2010; Wilson, Johnson, & Francis, 2018; Žagar & Križaj, 2005). The electric pulse amplitude started at 30mA and was increased by 10mA until maximal Dm was reached. A 30 s resting period was allowed between electrical stimuli to avoid potentiation effects (Wilson et al., 2018). The same assessor, who was familiar with the protocol, conducted the measurements.

**Jump tests:** Three variations of the jump test were conducted: (a) squat jump (SJ), (b) countermovement jump (CMJ), (c) drop jump (DJ). Three jumps were performed for each test variation on a force platform (S2P d.o.o., Ljubljana, Slovenija) that measured three-dimensional kinetic data; participants' hands were on their hips. The trial which produced peak jump

height was used for analysis. DJ was performed from a 35 cm height. Jump height (JH), peak power value ( $P_{\text{peak}}$ ), vertical take-off velocity ( $V_y$ ), and peak vertical force value ( $F_{\text{peak}}$ ) were recorded and used for analyses. Peak power and peak force were normalized by dividing peak power and peak force value by the corresponding weight of the participant.

Statistical analyses were performed using SPSS 21 (SPSS Inc., Chicago, USA). The Shapiro–Wilk test showed that the data were normally distributed. The percentage coefficient of variation (CV) and intra-class correlation (ICC) were calculated to verify the reliability of Tc, Dm, and JH for individual jump variation. For this study, a CV <20% was considered a good reliability and an ICC of <0.50, between 0.50–0.75, between 0.75–0.90, and >0.90 were considered poor, moderate, good, and excellent, respectively.

Pearson correlation was used independently for women and men to check the level of association between TMG parameters and JH,  $P_{\text{peak}}$ ,  $V_y$ , and  $F_{\text{peak}}$  for each jumping variation. Correlation coefficient values <0.10 were considered as trivial, 0.10–0.30 as small, 0.30–0.50 as medium, and >0.50 as large. Significance level was set at  $p < .05$ .

## RESULTS

All statistical assumptions were met for the analyses. CV and ICC revealed good to excellent reliability for TMG (for Tc CV = 1.0%–13.0%, ICC = 0.78–0.83; for Dm CV = 1.0%–19.8%, ICC = 0.63–0.89), and jump tests (for CMJ CV = 1.0%–14.0%, ICC = 0.98; for SJ CV = 1.0%–15.0%, ICC = 0.90; for DJ CV = 2.0%–19.0%, ICC = 0.92).

Descriptive statistics from TMG assessments and jumping performance are shown in Table 1. Statistically significant differences were found between sex for JH and  $V_y$  in CMJ ( $p < .05$ ), Dm in ES ( $p < .05$ ), and Dm in VM ( $p < .05$ ). Significant associations between TMG parameters and

jumping performance for men are shown in Tables 2–4 and for women in Table 5.

Significant large and positive correlations were found between Dm of ES and jump height ( $r = .679$ ,  $p = 0.003$ ), peak power ( $r = .611$ ,  $p = 0.009$ ), and vertical take-off velocity ( $r = .681$ ,  $p = 0.003$ ) for CMJ (Table 2). Thus, higher jump, with higher power production and higher vertical take-off velocity are associated with higher Dm values which correspond to lower muscle stiffness.

Significant moderate and positive correlation was found between Tc of ES and peak power ( $r = .495$ ,  $p = 0.043$ ) for DJ (Table 3). Higher peak power is associated with longer Tc when performing DJ.

Significant large and negative correlation between Tc of BF and vertical take-off velocity ( $r = -.507$ ,  $p = 0.038$ ) was found in SJ, indicating that shorter Tc is associated with higher vertical take-off velocity. However, significant moderate and positive correlation between Tc of VL and vertical take-off velocity ( $r = .483$ ,  $p = 0.049$ ) was found (Table 4).

Significant large and positive correlations between Dm of ES and jump height ( $r = .579$ ,  $p = 0.015$ ), peak power ( $r = .618$ ,  $p = 0.008$ ), and vertical take-off velocity ( $r = .588$ ,  $p = 0.013$ ) were found, indicating that superior jumping performance is associated with higher Dm values which correspond to lower muscle stiffness. Additionally, significant large and positive correlation between Dm of VL and vertical take-off velocity ( $r = .539$ ,  $p = 0.026$ ) was found, indicating that higher vertical take-off velocity is associated with higher Dm values which correspond to lower muscle stiffness.

Significant moderate and negative correlation between Dm of VL and jump height ( $r = -.457$ ,  $p = 0.032$ ) in DJ was found for women (Table 5). Thus, higher jumps are associated with lower Dm which corresponds to higher muscle stiffness. No significant correlations were found

between TMG, CMJ, and SJ (all  $p > 0.05$ )  
for women, respectively.

Table 1  
*Performance characteristics' Mean  $\pm$  SD during the CMJ, DJ, SJ, and TMG measurements.*

Measure	Variable	Male (n = 17)	Female (n = 22)
CMJ	JH (m)	0.32 $\pm$ 0.05*	0.28 $\pm$ 0.04
	P <sub>peak</sub> (W/kg)	47.09 $\pm$ 4.39	44.28 $\pm$ 4.69
	Vy (m/s)	2.50 $\pm$ 0.17*	2.39 $\pm$ 0.13
	F <sub>peak</sub> (N/kg)	24.95 $\pm$ 2.36	25.26 $\pm$ 3.04
DJ	JH (m)	0.26 $\pm$ 0.04	0.27 $\pm$ 0.05
	P <sub>peak</sub> (W/kg)	70.01 $\pm$ 14.43	72.05 $\pm$ 9.23
	Vy (m/s)	2.28 $\pm$ 0.20	2.30 $\pm$ 0.13
	F <sub>peak</sub> (N/kg)	56.45 $\pm$ 11.34	56.96 $\pm$ 7.98
SJ	JH (m)	0.31 $\pm$ 0.06	0.29 $\pm$ 0.06
	J P <sub>peak</sub> (W/kg)	48.22 $\pm$ 6.39	47.45 $\pm$ 6.18
	Vy (m/s)	2.39 $\pm$ 0.20	2.30 $\pm$ 0.15
	F <sub>peak</sub> (N/kg)	23.54 $\pm$ 2.40	24.06 $\pm$ 2.36
TMG	Tc BF (ms)	21.50 $\pm$ 3.86	24.30 $\pm$ 6.36
	Tc ES (ms)	14.76 $\pm$ 1.37	14.57 $\pm$ 1.53
	Tc RF (ms)	19.89 $\pm$ 2.97	20.53 $\pm$ 2.80
	Tc VL (ms)	17.27 $\pm$ 1.65	16.69 $\pm$ 1.33
	Tc VM (ms)	18.89 $\pm$ 1.76	18.21 $\pm$ 1.40
	Dm BF (mm)	4.11 $\pm$ 1.75	4.03 $\pm$ 2.05
	Dm ES (mm)	5.20 $\pm$ 1.60*	4.19 $\pm$ 1.25
	Dm RF (mm)	5.96 $\pm$ 2.11	5.42 $\pm$ 1.50
	Dm VL (mm)	4.66 $\pm$ 1.47	4.10 $\pm$ 1.13
	Dm VM (mm)	6.24 $\pm$ 1.33*	4.95 $\pm$ 1.18

*Note.* CMJ – counter movement jump; DJ – drop jump; SJ – squat jump, TMG – tensiomyography; JH – jump height; P<sub>peak</sub> – peak power; Vy – vertical take-off velocity; F<sub>peak</sub> – peak force; \* $p < 0.05$ ; Tc – contraction time; Dm – maximal radial displacement; BF – biceps femoris; ES – erector spinae; RF – rectus femoris; VL – vastus lateralis; VM – vastus medialis.

Table 2  
Pearson correlations between TMG and CMJ for men.

		JH (m)		P <sub>peak</sub> (W/kg)		Vy (m/s)		F <sub>peak</sub> (N/kg)	
		r	p	r	p	r	p	r	p
Tc	BF	-.321	.210	-.225	.386	-.219	.397	-.039	.880
	ES	.196	.450	.395	.117	.290	.258	.255	.323
	RF	-.158	.545	-.195	.454	-.206	.429	.008	.977
	VL	.250	.333	.250	.333	.278	.280	.329	.197
	VM	.357	.159	.295	.251	.310	.226	.210	.418
Dm	BF	-.427	.087	-.095	.718	-.398	.113	.036	.891
	ES	.679	.003*	.611	.009*	.681	.003*	.051	.845
	RF	.079	.762	.131	.617	.044	.865	.092	.725
	VL	.267	.301	.432	.083	.291	.258	.283	.271
	VM	.069	.792	.168	.519	.066	.801	.273	.290

Note. JH – jump height; P<sub>peak</sub> –peak power; Vy – vertical take-off velocity; F<sub>peak</sub> –peak force; r – Pearson's correlation coefficient; \**p* <.05; Tc – contraction time; Dm – maximal radial displacement; BF – biceps femoris; ES – erector spinae; RF – rectus femoris; VL – vastus lateralis; VM – vastus medialis.

Table 3  
Pearson correlations between TMG and DJ for men.

		JH (m)		P <sub>peak</sub> (W/kg)		Vy (m/s)		F <sub>peak</sub> (N/kg)	
		r	p	r	p	r	p	r	p
Tc	BF	-.478	.052	-.104	.690	-.424	.090	.138	.596
	ES	.244	.346	.495	.043*	.120	.645	.388	.124
	RF	.014	.957	.145	.579	-.282	.274	-.070	.789
	VL	.258	.318	.251	.330	.181	.488	.239	.355
	VM	.354	.163	.148	.571	.440	.077	-.165	.528
Dm	BF	-.161	.536	-.024	.928	-.119	.650	.166	.525
	ES	.205	.430	.320	.211	.368	.147	.298	.245
	RF	.282	.273	.292	.255	.032	.904	.115	.661
	VL	.254	.325	.273	.290	.236	.361	.329	.198
	VM	.133	.610	.096	.714	.313	.221	.142	.587

Note. JH – jump height; P<sub>peak</sub> –peak power; Vy – vertical take-off velocity; F<sub>peak</sub> –peak force; r – Pearson's correlation coefficient; \**p* <.05; Tc – contraction time; Dm – maximal radial displacement; BF – biceps femoris; ES – erector spinae; RF – rectus femoris; VL – vastus lateralis; VM – vastus medialis.

Table 4  
Pearson correlations between TMG and SJ for men.

		JH (m)		P <sub>peak</sub> (W/kg)		Vy (m/s)		F <sub>peak</sub> (N/kg)	
		r	p	r	p	r	p	r	p
Tc	BF	-.357	.160	-.300	.241	-.507	.038*	-.025	.924
	ES	.044	.867	.105	.687	.171	.511	-.068	.797
	RF	-.332	.192	-.241	.351	-.160	.540	.000	.999
	VL	.449	.070	.385	.127	.483	.049*	.136	.603
	VM	.210	.419	.091	.728	.220	.397	-.241	.351
Dm	BF	-.151	.564	-.074	.776	-.393	.118	.151	.563
	ES	.579	.015*	.618	.008*	.588	.013*	.231	.373
	RF	.062	.813	.211	.416	.188	.471	.373	.140
	VL	.460	.063	.520	.032	.539	.026*	.286	.266
	VM	.459	.064	.417	.096	.163	.532	.322	.208

Note. JH – jump height; P<sub>peak</sub> – peak power; Vy – vertical take-off velocity; F<sub>peak</sub> – peak force; r – Pearson's correlation coefficient; \*p < .05; Tc – contraction time; Dm – maximal radial displacement; BF – biceps femoris; ES – erector spinae; RF – rectus femoris; VL – vastus lateralis; VM – vastus medialis.

Table 5  
Pearson correlations between TMG and DJ for women.

		JH (m)		P <sub>peak</sub> (W/kg)		Vy (m/s)		F <sub>peak</sub> (N/kg)	
		r	p	r	p	r	p	r	p
Tc	BF	.031	.890	.207	.354	-.064	.776	-.006	.978
	ES	.063	.781	.037	.870	-.031	.891	-.072	.750
	RF	.164	.465	.043	.848	-.040	.860	-.197	.380
	VL	-.161	.474	.108	.632	-.256	.250	.184	.411
	VM	.269	.226	.061	.789	.316	.152	-.215	.336
Dm	BF	.031	.891	.026	.909	.116	.609	-.059	.793
	ES	-.093	.680	-.152	.499	-.020	.930	-.201	.371
	RF	-.145	.521	-.167	.458	-.230	.303	-.052	.818
	VL	-.457	.032*	-.111	.624	-.390	.073	.372	.071
	VM	.037	.871	-.060	.792	.130	.563	.007	.974

Note. JH – jump height; P<sub>peak</sub> – peak power; Vy – vertical take-off velocity; F<sub>peak</sub> – peak force; r – Pearson's correlation coefficient; \*p < .05; Tc – contraction time; Dm – maximal radial displacement; BF – biceps femoris; ES – erector spinae; RF – rectus femoris; VL – vastus lateralis; VM – vastus medialis.

## DISCUSSION

The results of the present study show: (a) large and positive correlations between Dm of the ES and jumping performance in CMJ and SJ for men; (b) moderate and

positive correlation between Tc of ES and peak power in DJ for men; (c) large and negative correlation between Tc of BF and vertical take-off velocity in SJ for men; (d) moderate and positive correlation between Tc of VL and vertical take-off velocity in

SJ for men; (e) large and positive correlation between Dm of VL and vertical take-off velocity in SJ for men; and (f) moderate and negative correlation between Dm of the VL and jump height in DJ for women.

We believe the cause for higher muscle stiffness of the ES associated with inferior jumping performance lies in possible lower back problems. All potential participants with lower back injuries were excluded from the study; however, there were some participants who reported minor lower back problems. A stiff ES could indicate lower back problems where motion of the injured structures is prevented after acute trauma or as a hyperactive response of the muscle to pain (pain-spasm-pain model) (Van Dieën, Selen, & Cholewicki, 2003). It is plausible that participants without lower back problems produced more power and velocity during the support phase of CMJ and SJ, and thus reached higher jump height in contrast to participants with lower back problems. The activation of ES is supposed to enhance vertebral stability, allowing effective arm and leg movements as well as effective trunk extension (Shinkle, Nesser, Demchak, & McMannus, 2012) and increased jumping performance. Therefore, healthy trunk extensors are important for jumping performance. However, because we did not diagnose lower back muscle problems with other diagnostic tools in our study, it was impossible to demonstrate direct associations between lower back problems and jumping performance. According to point (b) of our results, it could be claimed that force produced in ES is more important than contraction time for power production in DJ. This could indicate that it is more important to pre-activate the back muscles for DJ rather than activate them fast at floor contact. However, contraction time for the same muscle lacked significance for vertical take-off velocity and jump height. Therefore, it is impossible to associate lower contraction

time of ES with superior DJ performance. One of the challenges in jumping is to find a compromise between keeping the shortening velocities (contraction times) of the muscles low, because this might decrease the force and consequently decrease the work, and maximizing them to optimize the vertical velocity of the centre of mass (Bobbert & Van Soest, 2001).

Antagonistic muscle co-contraction is known to increase the equivalent stiffness of a joint, thus stabilizing the joint and giving support to the agonistic muscles. In SJ, BF works as an antagonistic muscle whereas VL is one of four heads of the quadriceps muscle that works as an agonistic muscle. The hamstring muscles have to contract fast in order to give full support to the knee extensors; therefore, it is plausible that the shorter contraction time of BF is important for the vertical take-off velocity in SJ. Muscle action in vertical jump is to some extent mechanically linked. It has been found that changing activation timing of certain muscles (i.e., hamstrings) by as little as 2–3 milliseconds results in a marked (over 10%) difference in jump height (Prokopow, Szyniszewski, & Himeno, 2005). The control of m. vasti, m. soleus, hamstrings, and plantar flexors were found to be especially important for coordination in jumping. The strength of the vastus medialis and rectus femoris (Bradley, Olsen, & Portas, 2007; De Ruyter, Vermeulen, Toussaint, & De Haan, 2007; Earp et al., 2010) as well as activation of ES (Charoenpanich, Boonsinsukh, Sirisup, & Saengsirisuwan, 2013) during SJ has been suggested as a predictor of jump height.

It was hypothesized that higher muscle stiffness in knee extensors (e.g., VL) would predict superior jumping performance; however, our study failed to prove this. On the contrary, our results indicate that higher muscle stiffness is associated with inferior jumping performance. In SJ, the jump test which

excludes arm contribution and active pre-stretching in the explosive power outcome of the jump, higher muscle stiffness did not enhance jumping performance.

A number of limitations of the present study have to be considered. First, the act of vertical jumping requires whole body participation and complex recruitment of the leg, trunk, and arm muscles. Hence, muscle stiffness and contraction time are only two of the factors influencing jump performance and could be compensated for by other factors involved. Second, not all muscles of interest are measurable using the TMG method because TMG can measure only superficial muscles. Third, current findings can only be applied to gymnasts. Fourth, there are still questions to be answered about the external validity of the TMG technique for applications in sports performance (Macgregor, Hunter, Orizio, Fairweather, & Ditroilo, 2018); direct links between TMG and muscle function are not known at present.

## CONCLUSION

In the present study, the TMG parameters failed to predict jumping performance in our sample of female and male gymnasts. However, results indicate that healthy back muscles are very important for the explosive function of the leg muscle and, therefore, performance of jumping skills. The lower maximal radial displacement of the ES muscle could indicate back problems and be indicative of inferior jumping performance in gymnasts.

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# EFFECT OF DYNAMIC RANGE OF MOTION AND STATIC STRETCHING TECHNIQUES ON FLEXIBILITY, STRENGTH AND JUMP PERFORMANCE IN FEMALE GYMNASTS

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*Original article*

## **Abstract**

*The aim of this study was to determine the long term effect of dynamic range of motion (DROM) stretching technique and static stretching (SS) on hip range of motion (ROM), hip isometric strength and vertical jump performance in female gymnasts. In a randomized controlled trial eighteen gymnasts (age  $13 \pm 2$  years) were assigned to a DROM group ( $n=9$ ) or SS group ( $n=9$ ). Participants were assessed at baseline and again at completion of the intervention on: hip extension (HE), hip flexion (HF), 1RM isometric HF strength, squat jump (SJ) and split leap (SL). Results: DROM group improved statistically from pre- to post-test in right leg HE ROM ( $13.67 \pm 4.7$  vs.  $21.22 \pm 5.2$ ), right leg HF ROM ( $129.9 \pm 9.9$  vs.  $139.0 \pm 10.4$ ), hip isometric strength for the right leg ( $2.0 \pm 1.1$  vs.  $4.7 \pm 1.6$ ) and the left leg ( $1.7 \pm 0.7$  vs.  $4.1 \pm 1.6$ ). Jump performance was not affected by type of stretching. Significance was set at 0.05 (2-tailed) for all analyses. DROM was more effective in improving gymnastic performance variables than SS. Such information may assist in determining the applications of various stretching techniques in flexibility-trained female athletes.*

**Key words:** *Dynamic range of motion, gymnasts, young, performance, female.*

## **INTRODUCTION**

Stretching is commonly used by athletes as a part of their conventional warm-up routine, specially in sports requiring the ability to move comfortably through a large range of motion (ROM) (Sands, Caine, & Borms, 2003). Among all stretching techniques, static stretching (SS) has been the most common technique used in warm-up routines, however it has been criticised for impairing muscular performance (i.e. muscle power, sprint time and jump height) (Behm & Chaouachi, 2011). Therefore, more oriented dynamic techniques are recommended before activity for tissue health and performance

improvement (Behm & Chaouachi, 2011; Schleip & Müller, 2013).

The acute and chronic effect of SS on ROM is well established (Donti et al., 2018; Guissard & Duchateau, 2004; Knudson, 2006; Siatras, Papadopoulos, Mameletzi, Gerodimos, & Kellis, 2003; Yuktasir & Kaya, 2009). The acute effects of SS on ROM are primarily attributed to an increased stretch tolerance (Magnusson, 1998), as well as to changes in the passive stiffness of the musculotendinous unit. On the contrary, long-term extensibility of muscles due to stretching has been attributed to changes in fascicle length and pennation angle (Franchi, Atherton,

Maganaris, & Narici, 2016; Freitas, Andrade, Larcoupaille, Mil-homens, & Nordez, 2015; Simpson, Kim, Bourcet, Jones, & Jakobi, 2017). Although the effects of SS on ROM in various joints are widely scientifically supported, its effects on injury prevention (Pope, Herbert, Kirwan, & Graham, 2000; Small, Mc Naughton, & Matthews, 2008; Thacker, Gilchrist, Stroup, & Kimsey Jr, 2004; Weldon & Hill, 2003) and improvement of physical performance have been questioned.

The dynamic range of motion (DROM) technique is an active self-stretching method during which, a contraction by the antagonist muscle causes the joint crossed by the agonist muscle to move through the full ROM at a controlled, slow tempo (Murphy, 1994). DROM is a technique that takes advantage of reciprocal innervation. It begins from a neutral position, followed by a slow movement (4-5 seconds) of the limb to end range, a brief hold at end range (4-5 seconds), and, finally, slowly (4-5 seconds) moving the limb back to the original neutral position using an eccentric contraction. Most studies on DROM are focused on its short and long term effect on hamstring flexibility (Abdel-aziem, Draz, Mosaad, & Abdelraouf, 2013; Askar, Pais, Mohan, Saad, & Shaikhji, 2015; Davis, Ashby, McCale, McQuain, & Wine, 2005; Nishikawa et al., 2015), however there is a lack of research regarding its influence on sports performance.

In artistic gymnastics, the high performance demands entail a great technical requirement in which optimal combinations of muscle strength, balance and flexibility are essential. In this line, SS is the most common stretching technique used in gymnastics, however it has been showed detrimental before leaping performance (Di Cagno et al., 2010) and during run of vault (Batista Santos, Lemos, Lebre, & Ávila Carvalho, 2015) . In the last years research has focused on the short term effect of SS compared with other

stretching modalities (i.e. dynamic stretching, proprioceptive neuromuscular facilitation, whole body vibration) to increase flexibility and jumping performance in gymnastics (G. Dallas et al., 2014; George Dallas & Kirialanis, 2013; Donti, Tsolakis, & Bogdanis, 2014; Kinser et al., 2008; Morrin & Redding, 2013) . However, with the exception of Donti et al. (Donti et al., 2018), who studied the effect of two different SS techniques (continuous vs intermittent) on the ROM enhancement and vertical jump, no studies have examined the long term effect of other dynamic stretching technique compared to SS in gymnastics. Furthermore, there is a growing need for studies in females and this study addresses this gap in the literature. Since DROM stretching is a more natural way to elongate the muscle because of CNS engaging motor control and strength at end of ROM, it might be a more functional and specific method than SS for sports requiring large ROM movements.

The aim of the present investigation was to determine whether, hip ROM and isometric strength, vertical jump and technical leap is influenced by long term SS or DROM stretching training when applied as a part of a warm-up routine in female gymnasts. Such information may assist in determining the applications and limitations of various stretching techniques and programs in flexibility-trained athletes.

## METHODS

This is a longitudinal and experimental study aim to assess the effects of DROM versus SS techniques on specific performance variables in young female gymnasts. It was hypothesized that DROM stretching would present more beneficial effects on hip ROM and isometric strength compared to SS, and would be less detrimental for jump performance than SS.

For this purpose, eighteen female participants from a club of gymnastics

were randomly assigned to a SS group (n= 9) or a DROM group (n= 9). During 7 weeks and 4 times a week, DROM group performed DROM exercises, while SS group performed SS exercises. Participants were assessed at baseline and again at 7 weeks on: hip flexion (HF) ROM, hip extension (HE) ROM, 1RM isometric HF strength, squat jump (SJ) and split leap (SL). All participants were right leg dominant.

The selection of the 20 gymnasts was performed through a non-probabilistic, accidental type sampling. Inclusion criteria comprised: being a gymnast with a minimum of 4 years experience, willing to train a minimum of 10 hours a week, competing at the regional or national level and not presenting any diagnosed illness and / or injury.

Subjects and their parents were informed of the benefits and risks of the investigation prior to signing an institutionally approved informed consent document to participate in the study. Approval for the study was obtained from the Ethics Committee at the University of Valencia (H1542280432742/13-12-2018),

in accordance with the 1975 Declaration of Helsinki.

Due to injury, there were two dropouts, therefore 18 gymnasts were finally included in the study. The characteristics of the participants were as follows: age ( $13 \pm 2$  y), body height ( $150 \pm 10$  cm), and body weight ( $39.8 \pm 8.7$  kg), hours of training per week ( $13 \pm 2$  h) and years of practice ( $7 \pm 2$  y). No significant baseline differences were found between groups in terms of age, weight, height, hours/week practice or years of experience.

Prior to each stretching training intervention and tests measurements a standardized warm-up was performed, including 5 min of jogging at 60% of maximal heart rate measured with heart rate monitors

During the 7 weeks of intervention, both groups performed the same gymnastics training, except for the 30-min flexibility training. SS group continued performing the usual SS technique which was characterized by being passive and continuous. Exercises (Table 1) were performed alternatively and always in the same leg order (right and left).

Table 1  
*Exercises performed in the static stretching protocol.*

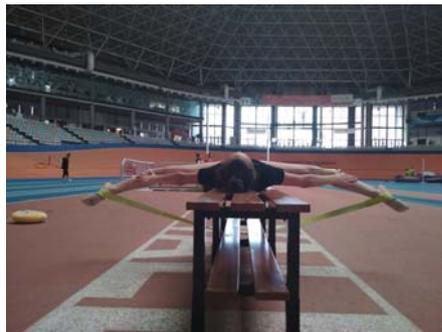
Exercise	Hip Motion	Reps x time (sec)	Total Time (min)
Split (bench) Posterior knee bent		1 x 90 (R) 1 x 90 (L)	6
Split (bench) Posterior knee extended	Hip Flexion and Extension	1 x 90 (R) 1 x 90 (L)	6
Penché		1 x 90 (R) 1 x 90 (L)	6
Abduction lying supine on bench with elastics	Abduction	2 x 90	3

\*R: Right; L: Left; sec: seconds.

Stretching exercises included: i.) 3 exercises addressing hip flexion (HF) and hip extension (HE): split supporting the front leg on a bench and back knee extended (Fig.1) and flexed, and penché with elastics and, ii) 1 exercise addressing hip abduction (HA): lying supine on a bench, legs in extension perform abduction with elastics (Fig.2).



*Figure 1.* Static Stretching exercise: Split supporting the front leg on a bench and back knee extended.



*Figure 2.* Static Stretching: Abduction exercise with elastics.

The total SS time was 21 min. Subjects were familiar with this stretching movement as they performed it regularly in their flexibility programs.

The DROM exercises included in the study to address the same joints than SS were: i) 6 exercises addressing HF and HE: lying supine on the floor HF (Fig.3) and

HE with hip neutral, external and internal rotation, 2 exercises addressing HA: lying supine HA with hip in neutral (Fig.4) and external rotation. For HF, HE and HA double of exercises were selected since the SG stretched both legs at the same time in all exercises, while DROM exercises implied to work one leg at a time.



*Figure 3.* Dynamic range of motion exercise: Hip flexion lying supine on the floor.



Figure 4. Dynamic range of motion exercise: Hip Abduction with hip in neutral.

Each stretch was performed at a very slow pace: 5 seconds for the concentric and eccentric phase, and 5 seconds for the isometric phase (end ROM position) (Askar et al., 2015; Bandy & Irion, 1994; Murphy, 1994). The isometric phase was carried out at a level of subjectively achieve 90% of the point of discomfort, where 0 represents “no stretch discomfort”

and 100% the “maximum imaginable stretch discomfort”. Each DROM exercise took 15 s. Since we wanted to work a similar stretching exercises and time than SS, each exercise was performed 5 times at each hip motion. The total amount of DROM stretching time was 20 minutes. Table 2 show the exercises chosen for the DROM protocol.

Table 2.

*Exercises performed in the dynamic range of motion protocol.*

Hip Motion	Leg	Reps x time (sec)	Total Time
Flexion + IR	R	5x 15	7 min 30 sec
	L	5x 15	
Flexion + ER	R	5x 15	
	L	5x 15	
Flexion + Neutral	R	5x 15	
	L	5x 15	
Extension + IR	R	5x 15	7 min 30 sec
	L	5x 15	
Extension + ER	R	5x 15	
	L	5x 15	
Extension + Neutral	R	5x 15	
	L	5x 15	
Abduction + Neutral	R	5x15	5 min
	L	5x15	
Abduction + ER	R	5x15	
	L	5x15	

\*R: Right; L: Left; sec: seconds; ER: External rotation; IR: Internal rotation

Since large ROM movements occur at flexibility-trained athletes and different planes of movement were applied in the exercises, a helper was needed to guide the

movement without any active intervention on it.

Both stretching protocols were controlled by two technical coaches and

one strength and conditioning coach. All DROM participants received one familiarization session (40 min) one day previous to the intervention protocol.

The gymnasts were asked to wear tight sports clothes, especially for the lower part of the body, in order to facilitate the location of the anatomical regions in the analysis of the videos with the Kinovea software. Both measurement tests took place at the time of day.

Before testing, we proceeded to measure weight (a model NMP scale, of 6mm tempered glass with accuracy of  $\pm 100$  g and capacity up to 180 kg) and height of the gymnasts.

For the measurement of jumping height, distance from greater trochanter to big toe in full plantar flexion (lying supine) and distance from greater trochanter to floor, from the standing in squat position, a flexible and roll-up measuring tape (350cm long and 3cm wide of the JUNGEN brand) was used.

The tests were applied in the following order: i.) Hip extension lying prone with knee bent  $90^\circ$ . The three anatomical points to measure the angle were: greater trochanter, initial and final position of head of fibula bone; ii.) Hip flexion lying supine with leg extended and neutral spine. The three anatomical points to measure the angle were: greater trochanter, initial and final position of head of fibula bone; iii.) Split leap with back leg in extension. A double step was made previous the split leap. Flying time was measured; iv.) Squat jump. The gymnast had to place the legs shoulder width apart, the arms in jug and the knees flexed to  $90^\circ$ . All subjects made three attempts (30 s rest between jumps), all of them were analyzed to keep the best mark; v.) 1 RM Isometric hip flexion strength. The gymnast in the supine position with HF at  $90^\circ$  and dorsiflexion of the ankle. It was carried out by means of a Mutronic CTSR 100 load cell (Mutronic S.A, Madrid, Spain) which was connected to a monitor. The cell was placed on the subject by means of a hook

attached to the malleoli of the ankle. The gymnast performed a 3 seconds maximum HF strength, while the researcher held the load cell.

For ROM measurement, one digital camera was placed 3 meters away, perpendicular to hip point and 10 cms height. The Kinovea Video Analysis Software (v.0.8.15) was used to measure joints angles during the test movements. We used 2D video analysis to measure ROM, as opposed to goniometer, for two reasons: firstly, it has become very common as a simple, inexpensive, and reliable alternative for researchers, rehabilitation professionals, and coaches to investigate athletes' ROM (Damsted, Nielsen, & Larsen, 2015; Elrahim, Embaby, Ali, & Kamel, 2016) and secondly, data obtained from this method would be more reproducible since coaches were used to capture videos and analyzed them at Kinovea's to provide immediate feedback to gymnasts in order to improve performance. Reflective motion analysis markers were placed on: greater trochanter, lateral malleolus of the fibular bone and styloid process of the ulna bone.

The same person was responsible for placing the marks to all participants and made sure they did not move or detached from the skin during the performance of body movements.

The app My jump 2 (v.3.6) (Balsalobre-Fernández, Glaister, & Lockey, 2015) was used for SJ and SL measurement. It has been validated with almost perfect reliability compared to platform forces, being considered the gold standard for measuring jump height (Balsalobre-Fernández et al., 2015; Gallardo-Fuentes et al., 2016). It was installed on an Xiaomi Redmi 4X with the version of the operating system Android 6.0 Marshmallow (Xiaomi, Inc., Pekin, China).

The load cell with a tensile and compression force sensor, 1000 N capacity and a measurement error of 1%, was used to obtain the 1RM isometric HF strength.

The load cell was connected to a monitor (Mutronic Sp 51 HiLine) to observe the values of the force applied. An ankle wrap with a hook was used to join the load cell to the subject's ankle (Fig. 5).



Figure 5. Maximal isometric hip flexion strength measured with a load cell.

A goniometer Baseline® HiRes™ 360° ISOM (STFR) with the accessory 12-1016 (Fabrication Enterprises, Inc. Baseline Absolute Axis Attachment) was used to measure 90° hip flexion from the horizontal plane in the supine lying position.

The storage of the information and analysis was performed on a Lenovo ideapad 520S with the version of the operating system Windows 10 Home (Lenovo Group Ltd. Hong Kong, China).

All data are presented as mean  $\pm$  SD unless otherwise stated. Assumptions of normal distribution, sphericity of data and covariate analysis were checked accordingly.

Greenhouse-Geisser correction to the degrees of freedom was applied when violations to sphericity were present. Given the variability in the Pre-test intervention, one way ANCOVAs were used to assess if there were differences at post-test between the two groups (DROM vs. SS) for HE ROM, HF ROM, 1RM HF isometric strength, SJ flight height and SL flight time. Where ANCOVAs' assumptions were violated Mixed 2 x 2 (Group by Time) ANOVAs were used.

Significance was set at 0.05 (2-tailed) for all analyses. The effect sizes for one way ANCOVAs and repeated measure

ANOVA's were calculated as partial eta squared ( $\eta^2_p$ ), using the small = 0.02, medium = 0.13 and large = 0.26 interpretation for effect size.

All data analysis was conducted using the statistical packages for social science (SPSS Version 20).

## RESULTS

In the ROM HE performed with the right leg (Fig. 6), there was a significant group x time interaction ( $F_{(1,16)} = 7.29$   $p = 0.016$ ,  $\eta^2_p = 0.31$ ). Follow-up tests revealed that SS group did not change significantly from pre- to post-test ( $16.77 \pm 3.8$  vs.  $18.67 \pm 3.6$  degrees), however, mean values for the DROM group increased significantly at post-test ( $13.67 \pm 4.7$  vs.  $21.22 \pm 5.2$ ). Analysis of Ancova showed no significant statistical differences in post-intervention ROM HE with the right leg between the groups when adjusted for pre-intervention ROM HE with the right leg ( $p = 0.062$ ).

Likewise, in the ROM HE performed with the left leg, no significant interaction was detected ( $F_{(1,16)} = 0.77$   $p = 0.4$   $\eta^2_p = 0.05$ ). However, there was a significant main effect of time ( $F_{(1,16)} = 13.85$ ,  $p = 0.002$   $\eta^2_p = 0.46$ ) showing an increase in both groups from pre- to post-test. Analysis of Ancova showed no significant statistical differences in post-intervention ROM HE with the left leg between the groups when adjusted for pre-intervention ROM HE with the left leg ( $p = 0.43$ ).

Regarding ROM HF no significant interaction was detected ( $F_{(1,16)} = 0.89$   $p = 0.36$   $\eta^2_p = 0.05$ ) for the right leg neither for the left leg ( $F_{(1,16)} = 1.91$   $p = 0.19$   $\eta^2_p = 0.11$ ). However, there was a significant main effect of time for the right leg ( $F_{(1,16)} = 7.38$ ,  $p = 0.15$   $\eta^2_p = 0.32$ ) and also for the left leg ( $F_{(1,16)} = 16.82$ ,  $p = 0.01$   $\eta^2_p = 0.51$ ). Both legs showed an increase in both groups from pre- to post-test.

Regarding ROM HF for the right leg (Fig. 7) there was a significant group x

time interaction ( $F_{(1,16)}=6.46, p=0.022, \eta_p^2 = 0.29$ ). Follow up test revealed that SS group decreased 2.6 % from pre to post-test, while mean values for the DROM group increased 6.5% from pre- to post-test. Analysis of Ancova showed significant statistical differences in post-intervention ROM HF with the right leg between the groups when adjusted for pre-intervention ROM HE with the left leg ( $p < 0.005$ ).

Regarding ROM HF for the left leg (Fig.7) no significant interaction was detected ( $F_{(1,16)}= 1.55, p= 0.23, \eta_p^2 = 0.09$ ). However, there was a significant main effect of time ( $F_{(1,16)}= 15.36, p=0.01, \eta_p^2=0.49$ ) showing an increase in both groups from pre- to post-test, and group ( $F_{(1,16)}= 10.35, p=0.05, \eta_p^2=0.40$ ). Analysis of Ancova showed no significant statistical differences in post-intervention ROM HF with the left leg between the groups when adjusted for pre-intervention ROM HF with the left leg ( $p= 0.37$ ).

There was a significant group x time interaction on 1RM Isometric HF for the right leg  $F_{(1,16)}= 9.54, p = 0.007, \eta_p^2 = 0.37$  and the left leg  $F_{(1,16)}= 12.73, p = 0.003, \eta_p^2 = 0.44$  (Fig. 7). Follow-up tests revealed that SS group did not change

significantly from pre- to post-test ( $1.2 \pm 0.5$  vs.  $2.7 \pm 0.7$ ), however, mean values for the DROM increased significantly at post-test ( $2.0 \pm 1.1$  vs.  $4.7 \pm 1.6$ ) when performed with the right leg. When performed with the left leg, SS did not change significantly from pre- to post-test ( $1.1 \pm 0.4$  vs.  $2.0 \pm 0.9$ ), however, mean values for the DROM increased significantly at post-test ( $1.7 \pm 0.7$  vs.  $4.1 \pm 1.6$ ) (Fig.8).

No significant group x time interaction was found for SJ ( $F_{(1,16)}=0.54, p=0.47, \eta_p^2 = 0.03$ ). However, there was a significant main effect of time  $F_{(1,16)}=11.97, p=0.003, \eta_p^2= 0.43$ , showing an increase in both groups from pre- to post-test.

No significant group x time interaction was found for SL ( $F_{(1,16)}=1.03, p=0.32, \eta_p^2 = 0.06$ ). However, there was a significant main effect of group ( $F_{(1,16)}=8.38, p=0.11, \eta_p^2= 0.34$ ) on SL performance. The main values (SD) for the DS and SS were: at pre test 0.41 (0.07) seconds vs. 0.36 (0.04) seconds, at the post test 0.42 (0.06) seconds vs. 0.34 (0.05) seconds. Jump performance was not affected by type of stretching.

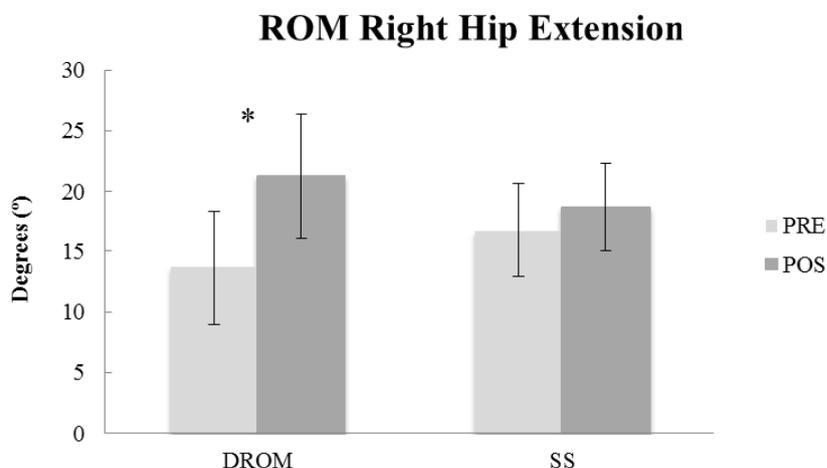


Figure 6 . ROM Right Hip extension of the DROM and SS at pre and post-test.  
 \* Significant difference between groups ( $p < 0.05$ ).

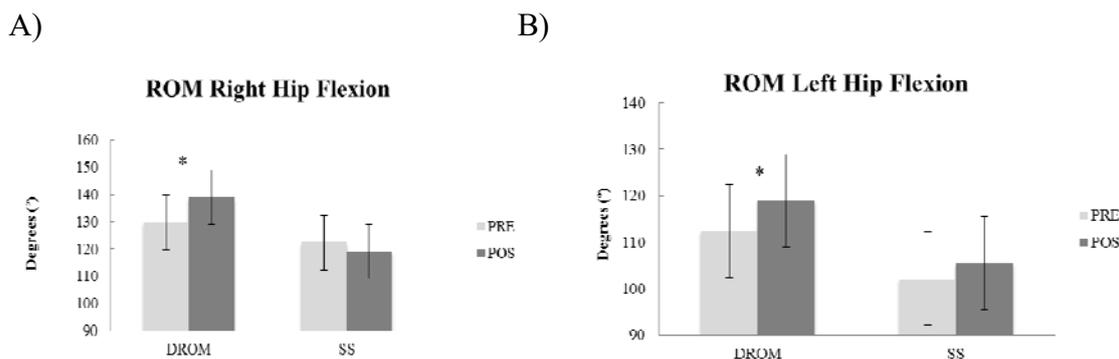


Figure 7. ROM right (A) and left (B) hip extension at pre- and post-test in DROM and SS groups.

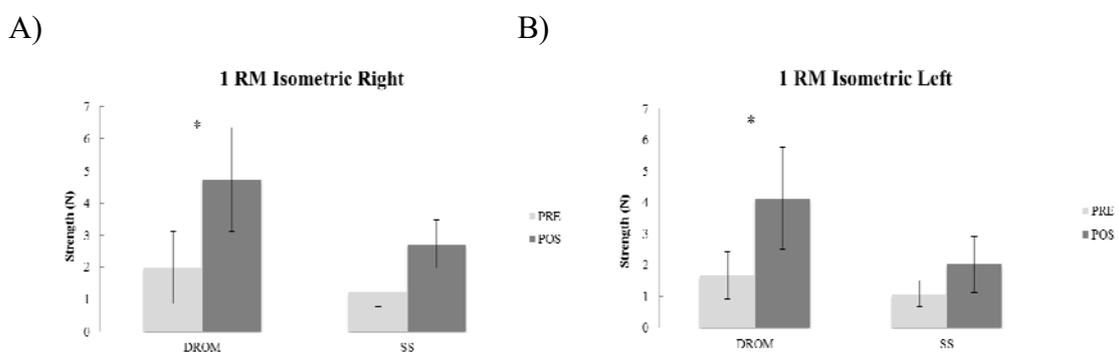


Figure 8. 1RM Isometric right (A) and left (B) strength at pre- and post-test in the DROM and the SS groups. \*Significant difference between groups ( $p < 0.05$ ).

## DISCUSSION

The main finding of this study was that DROM conferred a larger long-term improvement than SS in three key areas of gymnastics performance: hip ROM, hip isometric strength, and jump performance compared to SS. Thus it might be suggested that in young flexibility-trained female athletes, the influence of engaging the CNS and perform isometric strength at end ROM joint angles during DROM exercises may be a key issue in providing more positive performance effects than SS.

DROM was better at increasing hip ROM than SS. Askar et al. (2015) and Scott Davis et al. (2005) also compared the long effect of DROM on hamstring flexibility compared to other stretching techniques. Askar et al. (2015) who used DROM with the same time

stretching protocol than in our study [5 sec concentric (hip flexion movement)-5 sec isometric (holding hip flexion at end range of motion) -5 sec eccentric (hip extension movement)] concluded that although eccentric training, SS and DROM were all suitable to improve hamstring flexibility, the gains achieved by DROM exercise was significantly higher than eccentric training and SS. On the other hand, Scott Davis et al. (Davis et al., 2005) found that SS was better at increasing hamstring flexibility compared to DROM and PNF. However in their study they tested the hip ROM in a passive manner and the time stretching protocol for DROM was only 1 exercise x 30 sec (3 sessions a week). They considered it was not sufficient stretching time to significantly increase hamstring length in healthy individuals.

Another interesting finding of our study is that hip ROM improved

significantly in the dominant leg but not in the non-dominant. Santos et al. (Batista Santos et al., 2015) also found a high level of active and passive flexibility for the dominant (preferred) lower limb compared to the non-dominant (non-preferred) leg in rhythmic gymnasts. Flexibility asymmetries may appear as a result of the training type. The dominant leg of gymnasts, is the one executing a higher number of repetitions consisting on moving the leg in a fast controlled movement through the full ROM. The non-dominant leg is usually the supporting leg. Therefore, it can be speculated that the dominant leg might have received an added stimulus (DROM + regular training skills exercises) to increase the long term hip ROM in particular for active stretching exercise that it is subjected to, compared to the non-dominant leg that does a more passive static work. Moreover, dominant leg has in general more muscle mass compared to the counterpart and therefore the DROM training may have elicited a greater effect in the leg more constrained by greater muscle mass (17). These asymmetries could be addressed since it has been postulated that the non-dominant leg can achieve a similar performance to the dominant leg when properly stimulated (Cobalchini & Silva, 2008).

As opposed to hip ROM, both legs improved HF isometric strength, in this regard, Frutuoso et al. (Frutuoso, Diefenthaler, Vaz, & de la Rocha Freitas, 2016) found that the dominant limb in rhythmic gymnasts showed larger thigh girth and anatomical cross-sectional area, higher hip flexor and plantar flexor torque compared to the non-dominant limb. This discrepancy in the results may be due to the fact that they tested hip flexor torque at  $60 \text{ s}^{-1}$  while in our study HF 1RM isometric strength

Since holding a body figure for some seconds in rhythmic gymnasts is mandatory, it seems that isometric strength at end ROM is a key issue in gymnastics performance that DROM stretching

addresses efficiently. However, in the present study we did not have any measure of strength endurance, which is the specific form of strength displayed in activities which require a relatively long duration of muscle tension with minimal decrease in efficiency (Verkhoshansky & Siff, 2009). This variable is also a key component in rhythmic gymnastics.

VJ performance was increased with both stretching methods, 16% with DROM and 13.6% with SS. These results extend previous reports of studies that support the positive acute effects of DS to enhance many aspects of sports on jumping performance such as vertical jump (Hough, Ross, & Howatson, 2009; Jagers, Swank, Frost, & Lee, 2008; Morrin & Redding, 2013). However, these conclusions are constrained to acute enhancements in performance outcomes that were evident immediately or shortly after the stretching intervention was performed. On the other hand, and contrary to most SS studies showing a decrease in jumping performance after acute SS (Brusco, Pompermayer, Esnaola, Lima, & Pinto, 2018; Galazoulas, 2017), and the no influence on jump performance when a chronic SS intervention is applied (Bazett-Jones, Gibson, & McBride, 2008; Ikeda & Ryushi, 2018; Yuktasir & Kaya, 2009), our results showed that long term SS did improve SJ performance. This may be due to the fact that warm-ups take only a small time (25% approx.) of total training volume performed by a gymnast. Training sessions involve many other jumping and specific exercises that may counteract the long-term negative effects of a specific stretching protocol on jumping performance. Furthermore, our participants were also used to do those specific SS exercises therefore their negative influence might not be the same than when applied to non-trained healthy individuals (34).

The present study showed that when long-term DROM exercises are applied during warm-ups it produces slightly larger

improvements in VJ compared to SS, and furthermore, SS doesn't affect negatively VJ.

When we tested the SL, both stretching protocols improved the results from pre- to post- test, in fact, the SS decreased SL performance (-5.8%). In a study carried out by Di Cagno et al. (12), gymnasts performed the same technical leap than in our study and they found similar results: an approximately 7% decrease in the flight time after performing static stretches. Although, their results are related to acute effect the long-term effects of SS affected leap technical jump in the same way.

This specific technical jump requires a fast movement in a large hip ROM (one leg goes into HF and the other into HE), and unilateral non-dominant leg jump. Regarding the first issue, DROM stretches were performed in the same ROM hip movement in a slow tempo, contributing maybe to affect negatively the capacity of fast contraction in the inner ROM hip flexor and extensor muscles. The second issue maybe linked to the result of left HE asymmetry obtained in the tests. Gymnasts didn't improved left HE ROM which may affect negatively left unilateral jumping performance.

Thus SS may have the same long-term effect on the neurophysiological and mechanical factors underlying stretch response.

The strength of this intervention is that took place in a real-life training set-up, highlighting the external validity of the study. However, this study presents some limitations such as the sample size and the fact that we did not performed test-retest reliability assessment of the ROM measurements. However, we used the same tests and all of them were performed by the same person that had been doing those same testing procedures during the last 10 years at the Club. Although we did not track estrogen levels, which has been showed to influence joint and muscle laxity (Yim, Petrofsky, & Lee, 2018), the

number of athletes with the menarche were equally distributed at both groups. It would have been interesting having a control group, nonetheless it is very difficult in the sports performance environment having a group of gymnasts doing no stretching at all. So, due to the fact that static stretching is the gold standard stretching technique in gymnasts, we could consider it as a control group.

Further research should examine the acute effects of DROM exercises on sports performance variables and other type of athletes, and add measurements like musculotendinous stiffness and shear wave elastography to provide more information related to the cause of the results obtained.

## CONCLUSION

Although continuous stretching of long duration (>90 s) is commonly used in sports requiring large ROM movements (Suchilin & Arkaev, 2004) (e.g. artistic, rhythmic gymnastics, figure skating, diving and dance) the results of this study indicate that DROM stretching technique may be preferable when the aim is to achieve long-term hip ROM, hip isometric strength and no decrement on jumping performance (jumping performance in flexibility young trained athletes).

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## SHORT HISTORICAL NOTES XVII

Anton Gajdoš, Bratislava, Slovakia

Ph.D. Anton Gajdoš born on 1.6.1940 in Dubriniči (today Ukraine) lives most of his life in Bratislava (ex TCH, nowadays SVK). He comes from gymnastics family (his brother Pavel have world championship medals) and he devoted his life to gymnastics. His last achievement is establishment of Narodna encyklopedia športu Slovenska ([www.sportency.sk](http://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.



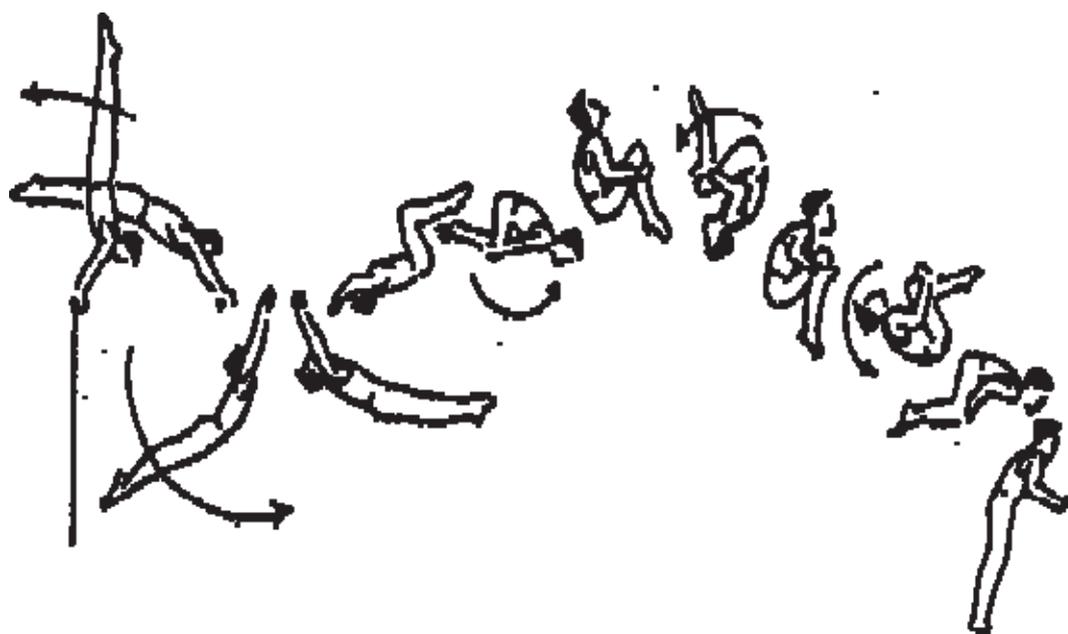
### **NIKOLAI YEFIMOVIČ ANDRIANOV (14 October 1952, Vladimir, Russia – 21 March 2011, Vladimir, Russia)**

Nikolay Andrianov started with gymnastics at age of 11. At World Championship in Ljubljana (Slovenia) 1970, he was member of Soviet Union team as reserve. But gymnastics fans knew when they saw him, he would be next gymnastics star. At European Championship in Madrid (Spain) in 1971 he won two gold medals on Vault and Pommel Horse. Until the end of his career at OG in Moscow (Russia) in 1980 he was decorated at major international competitions as OG, WC and EC with 45 medals. He is still the most decorated gymnast at OG with 7 gold, 5 silver and 3 bronze medals, all together 15. He marked a decade from 1970 until 1980 not only by his results, but also with new elements some named after him. He did double piked salto backward on floor, double salto backward with 1/1 turn on rings, double salto backward stretched on rings, salto forward with ½ turn and salto backward on high bar, triple salto backward tucked on high bar. From the above list it can be said he was perfect acrobat.

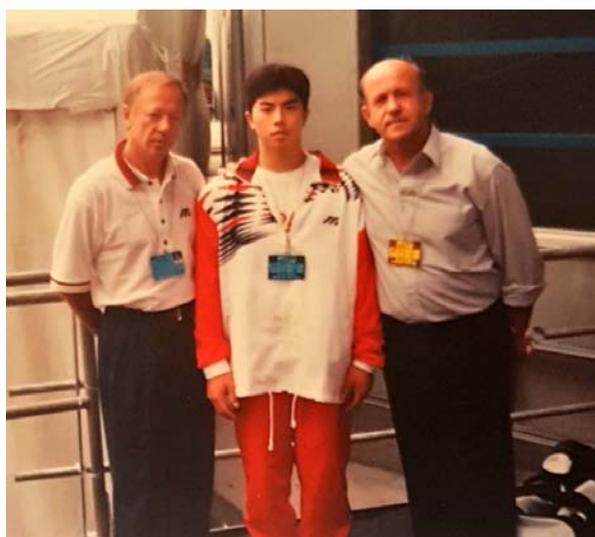
Soon after he finished career as gymnast he started with his coaching career. He was head coach of Soviet junior men's team 1981 – 1992, last two years also senior team. During his coaching work all the best Soviet juniors Scherbo, Misutin, Ivankov, Nemov were later also the best gymnasts competing for e.g. Belarus, Ukraina, Russia. All those gymnasts were also excellent acrobats.

Friendship with Mitsuo Tsukahara (Japan) lead Nikolay Andrianov to be a coach of Japan team and personal coach of Mitsuo's soon Naoya, who was decorated with medals at OG and WC.

In 2001 he returned to home town, where he was diagnosed with neurological disorder multiple system atrophy and died in pain as he could not move his arms, legs or talk.

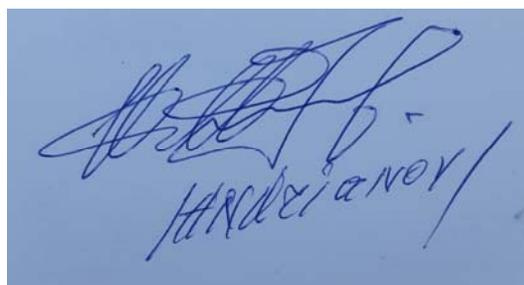


Triple salto backward tucked – Andrianov (FIG, Code of Points, MTC, 2016)



From left: Nikolay Andrianov, Naoja Tsukahara, Anton Gajdoš

His wife Ljubov Burda Andrianovna



Nikolay Andrianov's signature

## Slovenski izvlečki / Slovene Abstracts

Daniela Bento-Soares, Laurita Marconi Schiavon

## TELOVADBA ZA VSE: RAZLIČNE KULTURE, RAZLIČNI POGLEDI

Telovadba za vse (GfA) je telesna dejavnost, katere meje z vidika organiziranja niso jasno določene. Zato je treba razumeti koncept, sprejet v GfA, in njegovo vrednost za vsako družbeno skupino. Ta študija razpravlja o tem, kako različni narodni upravni organi (NGB) telovadbe pristopajo k GfA. V zvezi s opredelitvijo GfA, ki so jo sprejele države, smo povprašali 44 NGB, ki jih zastopajo splošni upravni in / ali posebni člani GfA. Uporabili smo spletni vprašalnik, ki ga gostimo v Googlu Forms®, v štirih jezikih. Odgovore smo analizirali s pomočjo Content Content, katere kategorije so bile ustvarjene po mešanem modelu. Njegova strategija je sprejela zaporedne konstrukcije razlage. Čeprav je v različnih določilih mogoče najti podobna načela GfA, so rezultati vprašalnika pokazali, da GfA pomeni različne stvari za vsako družbeno skupino, zato je težko razpravljati o enem samem razumevanju. Namesto tega je bolj smiselno razmišljati o GfA kot o naboru razumevanja. Zavedamo se, da vrednost GfA leži ravno v tolikšni raznolikosti pomenov in v vseživljenjski praksi gimnastike.

**Ključne besede:** telovadba za vse, pristop, državni organi upravljanja.

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Fernanda Raffi Menegaldo, Marco Bortoleto

## VLOGA ČASA IN IZKUŠENJ PRI VADBI TELOVADBE ZA VSE: GRAJENJE OBČUTKA SODELOVANJA

Cilj tega eseja je razpravljati o vlogi dveh socioloških kategorij, času in izkušnji v določenem okvirju netekmovalne telovadbe (telovadba za vse - GfA). Ko razumemo GfA kot skupinsko dejavnost, postane skupinska udeležba ključna prvina, ki udeležencem omogoča izmenjavo izkušenj v daljšem času. Zdi se, da je ta skupinska izkušnja v GfA neposredno povezana z razvojem in vzdrževanjem družbenih odnosov in spodbujanjem občutka pripadnosti, ki krepí GfA kot telesno prakso, ki kljubuje uspešnosti in logiki poudarjanja posameznika, ki jo v sodobni družbi pretirano doživljamo.

**Ključne besede:** netekmovalni šport, občutek pripadnosti, proces, sociologija.

Vasiliki Kaioglou, Fotini Venetsanou

## KAKO OCENJUJEMO GIBALNO PISMENOST PRI TELOVADBI? KRITIČNA OCENA ORODIJ ZA OCENO GIBALNE PISMENOSTI

Netekmovalna telovadba lahko prispeva k razvoju gibalne pismenosti (PL), ki je splošno priznana kot obetaven temelj dejavnega življenja. Ocenjevanje PL je prvi korak za načrtovanje in oceno učinkovitih telovadnih programov, katerih cilj je povečanje PL, in za opolnomočenje otroka s PL. Ta študija je poskusila izčrpno razčleniti razpoložljiva orodja za ocenjevanje PL. Ob iskanju v petih elektronskih bazah podatkov so bila ugotovljena tri večdelna orodja, ki poskušajo PL celostno oceniti in jih je mogoče uporabiti v telovadbi, ter jih kritično razčeni glede na njihovo vsebino, ciljno populacijo, izvedljivost in psihometrijo. Ta postopek je razkril, da so kljub podobnosti razvidne razlike med orodji za ocenjevanje, predvsem zaradi njihove glavne osredotočenosti, okvirja (-ov) uporabe, starostnih skupin, za katere so zasnovani, meril, uporabljenih za ocenjevanje PL. Poleg tega so bile v vsakem orodju opredeljene omejitve, vključno s časom upravljanja; potrebno usposabljanje ocenjevalcev; ni zasnovan za invalide; omejeni dokazi za njihovo psihometriko, ki vzbujajo pomisleke glede izvedljivosti, uporabnosti in tehnične ustreznosti teh orodij. Ker napredovanje PL zahteva veljavna in zanesljiva orodja za ocenjevanje, se zdi izboljšanje obstoječih, da bi se spopadli s svojimi pomanjkljivostmi in / ali razvoj novih zdravih, nujno.

**Ključne besede:** telovadba, orodje za ocenjevanje gibalne pismenosti za mlade, potni list za življenje, kanadsko ocenjevanje gibalne pismenosti, pregled.

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Jessica Simpson, Krista J. Munroe-Chandler, Kyle F. Paradis

## RAZMERJE MED STRASTJO IN PODOBO PRI MLADIH ORODNIH TEKMOVALCIH IN TEKMOVALKAH

Namen pričujoče študije je bil preučiti razmerje med strastjo in samopodobo pri mladih orodnih tekmovalcih in tekmovalkah. Merjencev je bilo 245 (moški,  $n = 10$ ; ženske,  $n = 235$ ), starih od 7 do 16. let, ki so tekmovali v ženski orodni telovadbi ( $n = 221$ ), moški orodni telovadbi ( $n = 7$ ), pa tudi skoki na veliki ponjavi in akrobatskih skokih ( $n = 17$ ). Telovadci so izpolnili vprašalnike, s katerimi so merili pogostost samopodob in njihovo strast do tekmovanja. Niz večkratnih regresijskih analiz je nakazal, da sta bila tako harmonična kot obsesivna strast pomembno povezana z vsemi petimi vrstami samopodob. Natančneje obsesivna strast je bila najmočnejše povezana s štirimi od petih vrst samopodob (CS, CG, MS in MG-A), harmonična strast pa je bila najmočnejše povezana z eno od petih vrst samopodob (MG-M). O rezultatih in posledicah strasti in samopodob v tekmovalnem mladinskem športu bi bila potrebna širša razprava.

**Ključne besede:** samopodoba, strast, mladinski šport, gimnastika.

Tim Haigis, Kerstin Schlegel

#### VPLIV VIDA NA UPRAVLJANJE GIBANJA PRI PRESKOKU

Zalet za povečanje hitrosti približevanja je sestavni del številnih športov. Cilj študije je bil raziskati ureditev zapletene gibalne naloge pri telovadbi in vpliv vida v teh procesih. Predpostavljeno je bilo, da se za optimizacijo postopka uporablja zlasti strategija, ki temelji na vidnem zaznavanju in vključuje podatke o času do stika, pridobljene iz spremenljivke tau. Pregledani so bili kinematični parametri 10 telovadcev, ki so izvajali premet naprej na preskoku. Razčlemba je pokazala, da se je v povprečju začel vidni nadzor tri korake pred oviro. Linearna regresija je pokazala, da je tau meja odvisna od hitrosti teka. Študija podpira idejo o ureditvi zaleta, ki temelji na vidni strategiji, v kateri je vpliv mize za preskok ključnega pomena. Telovadci so lahko prilagodili dolžino in trajanje koraka glede na hitrost gibanja, da bi olajšali optimalen prehod na odzivno desko in pozneje mizo. Pri tem je izrednega pomena vpliv hitrosti zaleta, ki se nanaša na vrednost tauja na začetku vidnega nadzora.

**Ključne besede:** premet naprej, vidni nadzor, zalet, kinematična razčlenitev.

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Miha Marinšek, Mitija Samardžija Pavletič

#### POVEZANOST MED ZNAČILNOSTMI KRČENJA MIŠIC IN SKAKALNO USPEŠNOSTJO TELOVADCEV IN TELOVADK

Ta študija je preučila povezavo med lastnostmi mišic krčenja in uspešnostjo skakanja v telovadnicah. V raziskavi je sodelovalo devetindvajset mednarodno izkušenih telovadk (56%) in moških (44%). Radialni premik in krčenje mišic biceps femoris, rectus femoris, vastus lateralis, vastus medialis in erector spinae so bili zbrani za oceno lastnosti mišic s pomočjo tenziomiografije (TMG). Poleg tega smo zabeležili vršno moč, višino skoka, hitrost navpičnega vzleta in navpično vršno silo pri skoku iz polčepa, nasprotnega gibanju in globinskega skoka. Parametri TMG niso napovedovali skakalne uspešnosti v našem vzorcu telovadk ženskega in moškega spola. V članku so obravnavane povezave med parametri TMG in skakalnimi zmogljivostmi.

**Ključne besede:** orodna telovadba, skok, polčep, globinski skok, skok iz nasprotnega gibanja spuščanja, eksplozivna moč.

Ana Ferri-Caruana, Noelia Roig-Ballester, Marco Romagnoli

## VPLIV DINAMIČNEGA IN STATIČNEGA RAZTEZANJA NA GIBLJIVOST, MIŠIČNO SILO IN SKOČNOST PRI TELOVADKAH

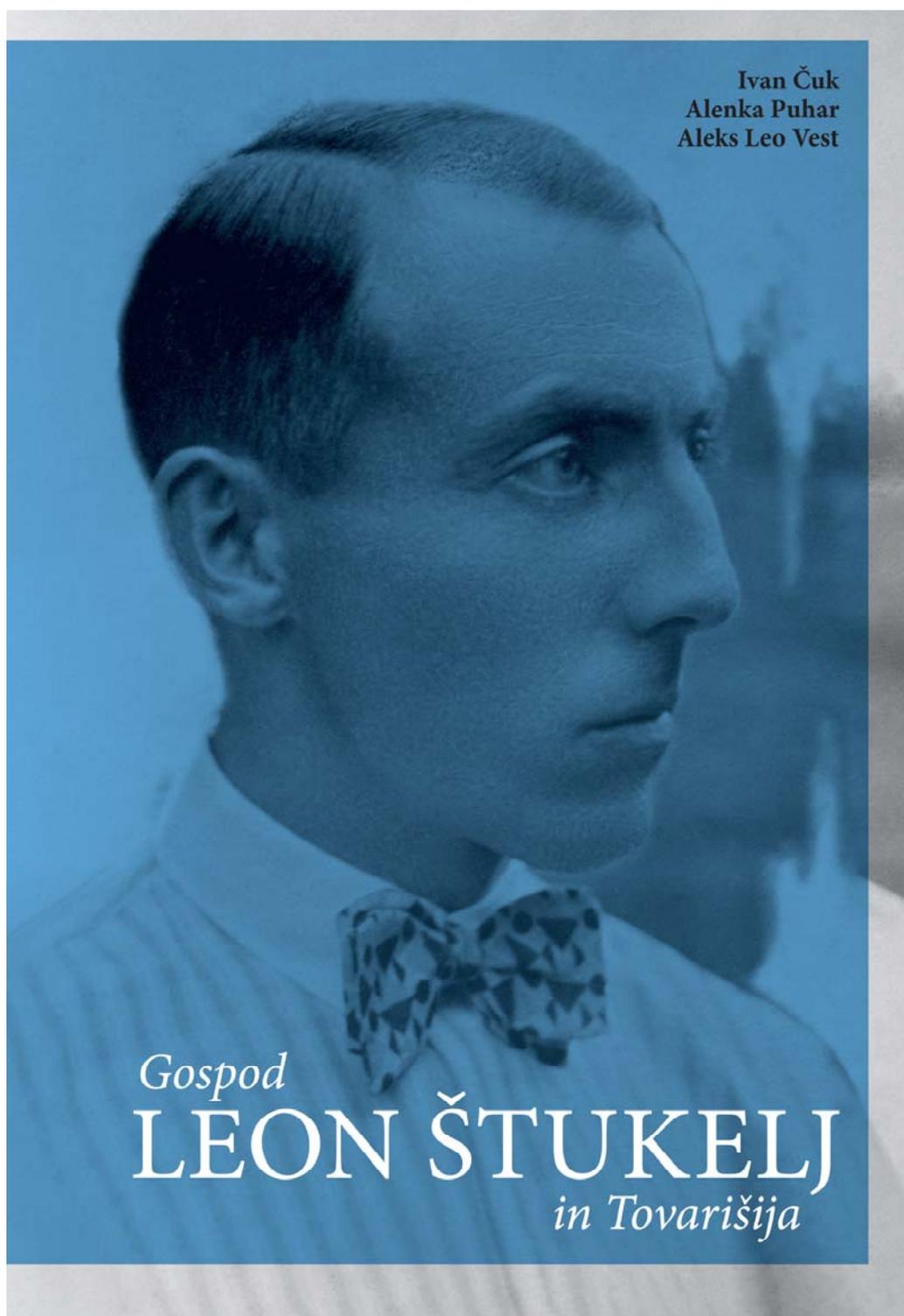
Namen študije je bil določiti dolgoročni učinek razteznih tehnik dinamičnega raztezanja (DROM) in statičnega raztezanja (SS) na razpon gibanja kolka (ROM), izometrične moči kolka in zmogljivosti navpičnega skoka pri telovadkah. V naključnem nadzorovanem preskusu je bilo osemnajst telovadk (starih  $13 \pm 2$  leti) dodeljenih skupini DROM ( $n = 9$ ) ali SS skupini ( $n = 9$ ). Udeleženke so bile izmerjene na začetku in po zaključku poskusa na: izteg kolka (HE), upogib kolka (HF), 1RM izometrična HF jakost, skok iz polčepa (SJ) in skok prednožno zanožno (SL). Rezultati: Skupina DROM se je statistično izboljšala na desni nogi HE ROM (pred  $13,67 \pm 4,7$ ; po  $21,22 \pm 5,2$ ), desne noge HF ROM (pred  $129,9 \pm 9,9$ ; po  $139,0 \pm 10,4$ ), izometrične moči kolka za desno noga (pred  $2,0 \pm 1,1$ ; po  $4,7 \pm 1,6$ ) in leva noga (pre  $1,7 \pm 0,7$ ; po  $4,1 \pm 1,6$ ). Na izvedbo skokov vrsta raztezanja ni vplivala. Za mejo verjetnosti je bila določena vrednost 0,05 (2-smerna). DROM je bil boljši pri izboljšanju spremenljivih gibalnih lastnosti kot SS. Takšni rezultati lahko pomagajo pri določanju uporabe različnih tehnik raztezanja pri športnicah, glede na cilje vadbe.

**Ključne besede:** dinamični razpon gibanja, mlade telovadke.

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Book about Leon Štukelj unknown life. Written by Ivan Čuk, Alenka Puhar and Aleks Leo Vest. Reviewed by dr. Lovro Šturm, ddr. Igor Grdina and Franček Jauk, prof reading by Borut Trekman, translation by Metka Čuk and designed by Klemen Kunaver. Published by Faculty of Sport, University of Ljubljana in december 2019.

## PARTS FROM SUMMARY

While working on book *Prevarani sokoli*, we searched for anything that included the key word 'Sokol' and was available in Slovenian public archives. When we visited the Pokrajinski arhiv in Maribor where we researched documents relating to Sokol Matica, Leon Štukelj's documentation did not come up since, amazingly, it does not include »Sokol« key word. When we gifted book *Prevarani sokoli* to Leon's daughter Lidija and asked her if we could get access to his archived documentation, she told us that all his documentation was already in the Pokrajinski muzej. Her encouragement and our research of the documentation showed that it was well worth collecting, organising and publishing it. Another lucky circumstance was that we got access to the documentation loaned to the Dolenjski muzej by Lidija Štukelj's family where we found a gray booklet.

Leon Štukelj's life ended in 1999. It has taken twenty years since his passing that we can finally make known what was on his mind but he never dared to canvas publicly. What prevented Leon Štukelj from publicly speaking about certain memories, we do not now, he never made any notes on this. He did, however, wrote on the front page of his gray booklet:

May these notes serve as a memory of her father to my daughter Lidija. They might also be used by a chronicler who wants to highlight the period that I experienced; finally, this is also my last will and desire.

This short yet important message made us think of fulfilling Leon Štukelj's last will and desire.

Leon Štukelj, a Slovenian intellectual, humanitarian, cosmopolite, top gymnast and athlete describes in his secret memoirs those experiences that were obviously not acceptable for publishing in the Socialist Federative Republic of Yugoslavia or that he himself didn't dare to publish even in the Republic of Slovenia.

His first book, *Mojih sedem svetovnih tekmovanj* (My Seven World Competitions), ends with the beginning of WWII. The book is very extensive and represents a true encyclopedia of gymnastics between the two wars. It debunked a few myths that sometimes still persist in our journalistic circles, such as that Nadia Comaneci was the first person to ever receive straight ten in gymnastics. His second book drafted in cooperation with Franček Jauk, *Prvih sto let* (My First One Hundred Years), in many respects repeats the pre-war story and partly attempts to explain what happened during and after the war by presenting Štukelj's thoughts on different issues as they emerged in conversation between him and his co-author. Leon Štukelj seemed to have some trouble explaining certain views which became clear in the Franček Jauk's film *Leon Štukelj in njegovo stoletje* (Leon Štukelj and His Century). When he is asked what he thinks about that dark period in Tito's Yugoslavia, he freezes for a moment, looks frightened and is at loss for words, then says that he doesn't know how come this dark period occurred.

Leon Štukelj's life path is immersed in gymnastics but this is not the only field of his activities. He has often been pictured as a gymnast, an Olympian, but rarely as a lawyer or a family man,

even though events and resources show that his family meant to him the most and he deeply cared for and about it.

Contact with the gym was the turning point in Leon Štukelj's life. Here he found his greatest pleasure and satisfaction. It gave him strong muscles and health, taught him to be a proud Slovenian and Yugoslav, connected him with the working people, with the people from the bottom and the middle, and provided him with the sense of understanding of his own situation at the time. According to Maslow (1976), we could say that before WWII, he reached the point of self-realisation. We could say that through his family, gymnastics and his judge job he went through all levels, but gymnastics and his judge job gave him that final points of respect and self-realisation.

Of course, hard work and successful conclusion of many cases eventually led to promotions and higher pay brackets. His memoirs show that in the judicial circles, freedom of speech applied, but he never expected that this freedom of speech would eventually be used against him. There was freedom of speech in the Kingdom of Yugoslavia and suppression of expressing one's thoughts in the Democratic Federative Yugoslavia. Not every country that calls itself democratic is really democratic.

Even though the court exonerated him of charges that he collaborated with the occupying forces, due to the ideological reform in the judiciary he was no longer suitable to serve as a judge and had to find another way. His court proceedings are an excellent document that shows how ideology overrode any evidence. Legal knowledge of prosecutors and judges (butchers, farmers, etc., could serve as judges) was obviously extremely modest, they served the new government as a tool to cleanse and bully their opponents. Leon Štukelj had to thank his friends in Maribor to offer him jobs and enable him to still work as a lawyer in different chambers. Here, he continued his excellent legal work, even though hidden behind party members. Nevertheless, these documents indicate that he enjoyed legal work and that he was well regarded by his co-workers and his superiors. In his post-war legal work, his humanitarian views still came to the fore which is obvious from the cases relating to housing in his company. Due to "socialist, labourer-friendly" legislation, he worked to the age of 67 which is more than is required even according to our legislation today. At the time of his retirement, his employment record shows that he had worked for 42 years, 11 months and 25 days – this too is more than is required by our current standards. As a matter of interest, Leon states in his book *Prvih 100 let*, on p. 173, that he had worked for 44 years, 7 months and 13 days. It is not clear, though, which period didn't count to his total number of years of service.

In the part that was not sent off, a few other important Leon's thoughts: "When you approached me (i.e., after the funeral of Dr Viktor Murnik in the office of Bojan Polak Stjenka) and I told you my surname, you shuddered with words "a, Štukelj!", as it happens when we meet someone we know very well by name but have never met the person before. By that, did you mean Štukelj the gymnast or Štukelj the prisoner?... I approved of the fight against the occupying forces but not the goal the Party had. Therefore, I reduced myself to an observer rather than participant on either side. But for the Party this was still not enough. It was politically naïve of

the Party to allow the proceedings against me to take place, this was not an honourable thing to do.”

Leon Štukelj's respect for the father of the Slovenian sport, Dr Viktor Murnik, is extraordinary: he sees him as the single person who stood behind Sokol members' successes in major competitions. When it came to awards, the Communist Party was keen not to talk about importance of the Sokol movement for the Slovenian nation and the development of sport, therefore they named the highest Slovenian award after Stanko Bloudek whose impact on the Slovenian nation and the development of sport in Slovenia is not even remotely comparable to Dr Viktor Murnik's. When Bloudek awards were bestowed for the first time in 1965, there were eleven recipients, among them Miroslav Cerar, Jelica Vazzaz and Sports Association Partizan Železničar in the gymnastics discipline. Among the award winners was also Rudolf Cvetko for his life achievements in fencing; in the explanation, his Olympic medals from 1912 and 1915 and his 15 years of being the president of the Fencing Association of Slovenia and Yugoslavia were mentioned. Leon Štukelj's achievements were forgotten whereas his court proceedings were not, and the Sokol idea was also dead. In 1997, sports authorities finally remembered Leon, after he had experienced the peak of his fame when he appeared in the Olympics in Atlanta in 1996 where he came to the stage with a spring in his step. Finally, there was a thought that he might be worthy of the most prestigious award in Slovenia, regardless of the fact that the International Olympic Committee awarded and recognised him as early as in 1987. In 1991, this honour among individual members of the Slovenian Olympic Committee was bestowed on Miroslav Cerar as the only other person.

But we are fortunate enough that Leon wrote down his thoughts about ideology and wanted them to be published. He encountered communism for the first time at the end of World War I when captured soldiers of the Austro-Hungarian monarchy returned from their captivity in Russia. The new political idea echoed and was discussed everywhere. Leon Štukelj writes: “without any knowledge of scientific Marxism, we evaluated communism from our common sense position. Of course, most people who came from poor families favourably viewed the propaganda for better life since the idea is basically humanitarian. However, communism also injected in people who were used to living in unity and had mutual respect and respect of property the sense of envy and a demand for equality. Sharp discussions among Dolenjska students were carried on without any understanding of how and why the existing situation evolved, the important thing was only to destroy the old because it was unjust. Thanks to those who opposed destruction (for no matter what reason) and to Leon, who always tended to philosophise and analyse, all arguments ”for” and “against” in long debates after exercise finally crystallised and the majority came to believe that revolution was not the only way out of this situation, or rather that revolution was a too risky cost for what was promised to us in a few carefully selected words. An important question emerged: can people still remain members of the Sokol club or Sokol in general if they support revolution that was supposed to bring down social differences that existed on the micro scale among Sokol members?” Leon continues: “Our upbringing, in and outside Sokol, truly did not ignite the passion for revolution in us. There was too much idealism and romanticism in our “social opponents” among Sokol members and not enough gaping differences to suffice for a sudden turn from “brotherhood” to “revolution”.

Everyone was in a situation where study and hard work could help them achieve good livelihood, with every option open to reach better and even the best positions. Social differences were actually negligible. The richest town's people had a trade and perhaps their own house, among public servants the best off were those in academic professions. These people of course lived well, from our perspective perhaps even luxurious. Luxurious because we didn't have more than just bare essentials. True, some didn't have even that and were struggling. Yet nobody was without a chance to get out of this situation by studying and working hard and reach a satisfactory or even luxury life of those who were best off. There was nothing like the capitalism we read about in brochures (Kautsky), hence there was no awareness of the "class enemy", there was no real division among us and therefore no such sharp contrast that would ignite hatred in us. All these facts, recognised on the rational and emotional level, showed us, and me in particular, that there was no need for a violent removal of these differences that would require revolutionary acts including, as a necessary consequence, leaving the Sokol organisation. The Sokol organisation was the most democratic of them all. The whole nation was in danger, not just one class, therefore Tyrš in Fugner rejected class conflict as a danger that could weaken the nation in its defence, and promoted the national question as the most important issue instead. There was too much idealism, romanticism and cultural refinement in me to turn overnight from a friend to a foe. If I followed the gospel spread by communists, I would have to become a class enemy and immediately leave Sokol. In my view, there was no objective necessity for this step, since we lived in modest but very orderly circumstances at home. After many discussions and debates, my view was agreed upon by many gymnasts in my inner circle of friends. We all thought that the achievement of national freedom, experienced by us so emotionally, was more that we could ever imagine to have.

The following memory cannot be considered a secret one as Leon Štukelj published it in his book *Prvih 100 let*, nevertheless, it is worth quoting (p. 184): "I did not hold it against the communists, there were ordinary people who were offered dreams and future that was actually not achievable. But I hold it against our former intellectuals that were my company at the time... Intelligent people should have known what was happening in the Soviet Union, that people were imprisoned and killed in large numbers there. People knew, but they overlooked it and still led our masses against the same social goals in a similar way."

Book *Prevarani sokoli* highlighted the fact that Sokols as an organisation were not part of the Liberation Front, that Sokol members were mainly patriotic and not ideological supporters of communism and as such weren't ideologically acceptable to the Communist Party, therefore the Party terminated the organisation. And this is exactly what Leon Štukelj confirms in his writing. *Politična oporoka Leona Štuklja* (The Political Last Will of Leon Štukelj) written by his son-in-law Franc Pauko was met with an avalanche of criticism in the media. Reading his hidden memoirs will let everyone come to their own conclusions on Leon Štukelj's real political last will.

Leon Štukelj first and foremost saw himself as a humanitarian. Even though the words humanist and humanism have many different meanings, Leon can be described as a humanist, with values

that are based on respect of human dignity and care for others. His documents reflect his awareness that human dignity begins with conception and lasts until death.

Maybe this last paragraph is the most important also for our current times and the future:

that human life is sacred and that if intellectuals want to be humanitarians they have to value life and condemn all crimes against people's lives.

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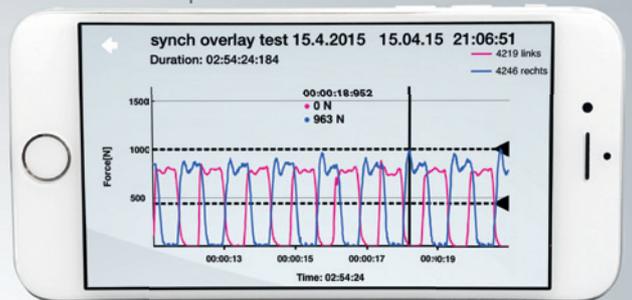
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