Science of Gymnastics Journal

vol. 15, num. 1, year 2023

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

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EDITORIAL

Dear friends,

Last year we moved to open editorial software that is hosted by Ljubljana University. We are still adapting to this new address and the new way of work. We apologise for any inconvenience that this move has created and hope to get everything running smoothly as soon as possible.

Please note that our address is

https://journals.uni-lj.si/sgj

We are still working as volunteers and splitting our duties with our younger coworkers. You may have noticed that the administrator has become very strict when articles are not prepared according to the guidelines. To avoid any prolonged delays in getting your article approved, please read the guidelines carefully and make sure to follow them.

We are still experiencing problems with our reviewers as, unfortunately, many of them have no time to review our submissions. I would like to appeal to you to please help us out. As a specialized journal, we have access to only a limited number of researchers. Let's all make an effort to be a part of the prominent scientific community on the Web of Science and SCOPUS!

This issue covers a diverse range of content, and as the editor, I particularly enjoyed reading the historical articles. We have an excellent article from Croatia on the development of gymnastics in their country up to the year 1903. The authors are mostly from Brazil, with the rest coming from Slovenia, Portugal, Japan, Turkey, and the USA.

Anton Gajdoš prepared his 26rd short historical note introducing Eberhard Gienger from Germany.

Just to remind you, if you cite the journal, its abbreviation in the Web of Knowledge is SCI GYMN J.

I wish you enjoyable reading and many new ideas for research projects and articles.

Ivan Čuk
Editor-in-Chief

DEVELOPMENT OF GYMNASTICS IN CROATIA UP TO 1903

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Original article *DOI:15.1.5-25*

Abstract

This manuscript aimed to show the development of gymnastics in Croatia up until 1903. This article provided a chronological description of the growth of gymnastics in Croatia from 1859 to 1903. In Osijek, Croatia's first gymnastics society was founded in 1865. Gymnastics were introduced into schools in the middle of the 19th century as a result of increased interest in physical education based on by the stronger development of civil society. 1874. was founded Croatian Sokol in Zagreb and gymnastics also became a part of a high school program. In Croatia, numerous gymnastics societies started to be established, including the Varaždin Sokol Gymnastic Society in 1878 and the Zadar Gymnastic Society in 1876. In Dalmatia, central Croatia, and Slavonia, new gymnastics societies have been founded. For example, the Croatian Sokol was founded in Bjelovar in 1884 and Makarska in 1894. Additionally, the gymnastics society took part in open workouts in Prague and Pariz. Women's gymnastics started on in 1891 in Croatian Sokol in Zagreb where exercises were conducted in three divisions, including simple exercises and those on the apparatus.

Keywords *artistic gymnastics, Croatia, history, "Sokol".*

ORIGINS OF GYMNASTICS IN CROATIA

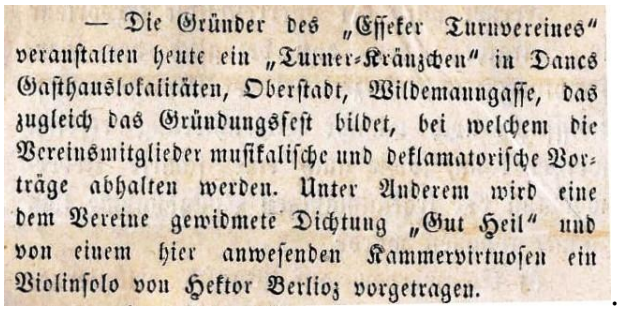
Organized gymnastics appeared somewhat later in areas inhabited by Croatians, than in other areas, inhabited by other European nations. Gymnastics and physical exercise, started appearing very early, as a form of gymnastics conducted by German and Austrian officers during their stay in the barracks. In the Military Frontier it was modelled from German Turner associations on one side, while gymnastics had a connection with firefighter tasks, which was also the case in some other countries (Iveljić, 2012: 10-15).

Time elapsed from the beginnings of organized gymnastics activities, to the foundation of the first association, has made its beginnings almost completely forgotten.

Beginnings of organized physical activity in Zagreb are tied to the year 1859. and Miroslav Friedrich Singer (1821. - 1876.) Institute for Physical Exercise. Although Singer educated a number of significant people in gymnastics, it took a long time to establish the first gymnastic society (*Gimnastika,* 1891: 11: 166).

First gymnastic society in Croatia was established in Osijek in 1865. Information that *Pervo društvo gombalach* will conduct the first gymnastic exercise in the pub "Danč", which shall also be a founding celebration, was published on the 23rd of

July in the year 1865 in the paper *Esseker Lokalblatt und Landbote, (Figure 1),* which was a local paper at the time. (*Esseker Lokalblatt und Landbote*, 1865: 58). The society was founded on the proposition of J. Wawerke, editor of the paper, under the name *Pervo društvo gombalacah [The first gymnastics club]* in Osijek. The announced exercise was conducted on September the 2nd, and the foundations for organized physical activity in the city of Osijek were placed. A request for approval of societies rules and regulations was prepared and submitted on September the 9th. Board of the society was elected on the first general meeting with Ladislav Molnar as the principal, Karlo Lehman as vice principal, Eduard Gal as leader (gymnastics teacher), Mato Danč as treasurer and J. F. Waverka as secretary (Firinger, 1974: 19: 1699).



— Die Gründer des „Eſſeker Turnvereines" veranſtalten heute ein „Turner-Kränzchen" in Dancs Gaſthauslokalitäten, Oberſtadt, Wildemanngaſſe, das zugleich das Gründungsfeſt bildet, bei welchem die Vereinsmitglieder muſikaliſche und deklamatoriſche Vorträge abhalten werden. Unter Anderem wird eine dem Vereine gewidmete Dichtung „Gut Heil" und von einem hier anweſenden Kammervirtuoſen ein Violinſolo von Hektor Berlioz vorgetragen.

Figure 1. Osijek, July 23rd, 1865., publication in the paper *Esseker Lokalblatt und Landbote* about the new society

The most important reason why other gymnastic societies could not develop properly, was a lack of gymnastic teachers, gymnastic apparatus, halls and playgrounds, lack of material funds in associations, and because of political disputes (Iveljić, 2014: 9).

A stronger development of civil society has initiated a higher interest in physical education, leading to incorporation of gymnastics in schools in the middle of 19th century. A new attitude towards human body can be discerned through incorporation of gymnastics as an obligatory class in public schools, on the basis of a law from the year 1874. Gymnastics also became a part of a high school program. Special attention was given towards construction of gymnasiums, leading to their development in most major settlements. A large number of exercises were performed with and on apparatus in sports halls, and during spring and summer, in open spaces. A new instruction has been issued for swedish system gymnastics, with a detailed list of elements of exercise.

An important gymnastic society was founded in Zagreb during the year 1862, Croatian singing association *Kolo*. Members of *Južni Sokol* [*South Sokol*] from Ljubljana visited the singing society *Kolo* during the ceremonial celebration of heroic death of governor Nikola Šubić Zrinski, which was held during 24th to 26th of November in 1866. Around 60 Slovenian Sokol members with their flag in Sokol uniform arrived in Zagreb, and were greeted heartily from Zagreb crowd. An idea of creation of a gymnastic society in Zagreb was proposed (Zeininger, 1892: 30).

The society has filed requests and amendments for the foundation of gymnastic section within the society, on numerous occasions, which the government rejected (Radan, 1973: 16: 1482).

CROATIAN SOKOL IN ZAGREB

The first agreement for the foundation of the society was in the city hall, on the incentive of Josip Fon (1846. - 1899.), with the mayor of Zagreb, Ivan Vončina. On the meeting held on July the 5th in 1874, creation of regulations was trusted to the committee. Temporary committee with priest Josip Torbar (1824. - 1900.) at the head, who became the first temporary president, undertakes an action to create the scoiety. The committee consisted of representatives (founders) Friedrich Miroslav Singer, Franjo Pečak (1841. - 1934.), Oto Jokuš and Đuro Kontak, and secretary Mirko Mikulčić (Bučar, 1925: 6). Appeal for registration of Society for Physical Exercise *Hrvatski Sokol* [*Croatian Sokol*] (Statuten des Agramer Turnvereines „Hrvatski Sokol“), along with regulations, was submitted on 18th of July. Society regulations were written bilingually, on Croatian and German languages (Pravila, 1874).


58.

PRISTUPNICA.

Gosp. Lad. Mrazović pristupio je družtvu za tielovježbu u Zagrebu „Hrvatski sokol“ kao podupirajući član.

U Zagrebu dne 18. Studena 1874.

U ime privremenoga odbora:

Jov. Torbar predsjednik.

Tiskom Dragutina Albrechta.

Figure 2. Membership application form of a member of Croatian Sokol in Zagreb, registered on November the 18th, 1874., under the number 58. (National University library in Zagreb).

Number of registered members soon reached 185 members, consisting of 19 founders, 66 executive members who partake in physical exercise and 100 backing members, who do not exercise, but support the association through membership fees (Bučar, 1925: 7).

First general meeting was held on December the 27th, 1874., in the pub “K Caru Austrijskom” in Zagreb. Ivan Vončina became principal, Josip Fon vice principal, Levin Rojčević secretary, Ivan Stožir account liquidator, Milan Lenuci apparatus guardian, Antun Stiasni treasurer, Đuro Kontak, Franjo Pečak and Friedrich Miroslav Singer became representatives, with Singer also being the leadern (Figure 3), (Hajdenak and Bučar, 1878: 1: 6).

Figure 3. Founders of *Croatian Sokol* in Zagreb. (Đuro Janči).

The society began training in Singer school of gymnastics located at former Strossmayer promenade in the upper Town. Gymnastic apparatus located there consisted of: wooden horizontal bar, still rings, parallel bars, pommel horse, vault horse, two training mats, stands with strip for horizontal jumps and a springboard, and a few smaller kettle bells (Bučar, 1925: 8).

It was decided that members clothes were simillar as of those in Sokol from Prague: baggy pants, short coat made from Russian linen, red shirt, small hat with a plume and a monogram and black shoes. For some time, a wide collar with a white tie was worn. After some time it was replaced by a tight army collar without a tie. (Bučar, 1925: 12; Primorac, 1875: 2).

Croatian Sokol in Zagreb began operating in January 1875. Gombanje, or strengthening, was conducted in accordance to a German method of Adolf Spies, in a building on Strossmayer promenade. City authorities allowed utilization of apparatus (Bučar, 1924: 3: 49).

Soon, more than a hundred members were exercising, with the first frontmen: Josip Fon (Figure 4), Wingerl, Vukišević, Žiga Stagl, Rudolf pl. Bekh, Gjuro Križ, Robert Weiss, Ivan Hörer, Božidar and Ivo Mallin. Through the year, the association organised a couple of excursions and designed an official flag. (Bučar, 1925: 11).

As there was no Croatian gymnastic terminology, Andrija Hajdenak wrote the first book about physical exercise on Croatian language. The book *Tjelovježba u pučkoj školi* [*Physical exercise in the public school*] written as instructions for teachers, „*kako metodično mogu poučavati u prostih vježbah, u koliko se one u školi izvesti dadu*“ [*"how methodically teach simple exercises, so they can be performed at school"*] (Hajdenak, 1875: 2).

ACTIVENESS OF OTHER GYMNASTICS SOCIETIES

Italian **Zadar Gymnastic Society** (*L' Associazione Zavratina di Ginnastica*) was founded on January the 20th, 1876 in Zadar. In the society regulations, care of gymnastics was on the first place. With good organisation, the members exercised in the amphiteatre of Guissepe Manzini on Nova Obala, where they made good progress (Marić - Meštrović, 2013: 70).

The year also commenced with exercises of Croatian Sokol in Zagreb, in a small gymnasium on Strossmayer walkway, on the South promenade. The association decided to hold a first sokol dance on February the 4th in 1876. First dance in costumes of Croatian Sokol was held on the premises of city shooting range in Zagreb. Name change was conducted by the beginning of April, and was approved on the 28th of that month with the name changed into **Zagreb Gymnastic Society Hrvatski sokol** (Bučar, 1925: 13; Radan, 1973: 16: 1455).

After the death of Singer, Prague Sokol recommended Čeh Franjo (František) Hochman for the positions of teacher and headmaster of the society, who was elected on March the 8th in 1876. He began to use Croatian language when teaching, and incorporated exercising by Tyršev sokol model. His effort has shown successful and the association began to visibly improve. (Bučar, 1925: 11).

First public gymnastics exercise with Croatian Sokol competition was held in Zagreb on the 15th of July in 1876, in the garden of civil shooting range. 30 members of the association demonstrated exercises on horizontal bar, parallel bars, jumping over vault horse, exercises in formations, and group exercises with sticks. This demonstration displayed to the public what gymnastics consists of. Hochman, Weiss, Kosirnik, Malin and Lenuci stood out in these exercises (Bučar, 1925: 19).

During consecration ceremony of the flag of singing society *Vila* in Varaždin on the 19th and 20th of May in 1877, visiting members of Zagreb Sokol society initiated an idea to start a new society. Along with members from Zagreb, students of Varaždin high-schools also participated in exercising,

while wearing a special gymnastics suit and led by gymnastics teacher Nilius. The Initiative board prepared rules and regulations for the foundation of Varaždinski Sokol on May the 27th. A temporary board was elected during October, with Slavoljub pl. Pump being the head of the board (*Sokol*, 1878: 2: 14; Bučar, 1925: 18).

First number of *Sokol* was published on January the 15th in 1878, under editorial work of Andrija Hajdenak and Franjo Hochman. With the creation of first journal of gymnastics, Hajdenak and Hochman highlited that physical exercises, mentally guided, should primarily be implemented in public schools, through them to the whole nation, as they developed and domiciliated in other, more developed nations. In addition, they wished the creation of gymnastic societies, throughout all of Croatia.

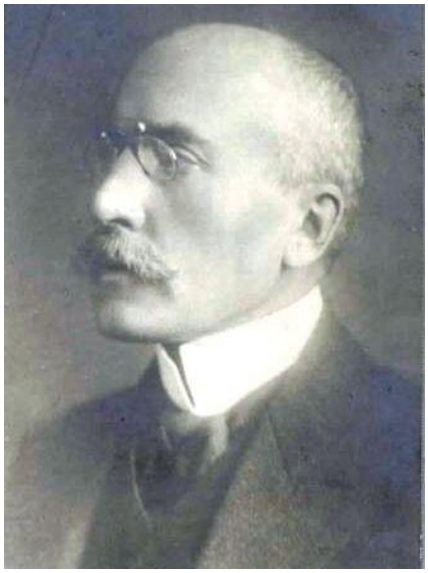


Figure 4. Frontman of Zagreb association Josip Fon.

After the foundation of gymnastic societies in Osijek and Zagreb, **Gymnastic Society Varaždin Sokol** was formed on the 1st of March in 1878, in Varaždin. On the first general meeting, Slavoljub pl. Plump was elected as principal, Stjepan Sekovanić as vice principal, Josip Polanec as treasurer and Josip Plantić as secretary. In the beginnings, the society had approximately sixty executive and backing members (Svoboda, 1923: 16; Bučar, 1925: 18).

FIRST INTERURBAN GYMNASTIC COMPETITION

First interurban public exercise, coupled with a competition was held on 29th of June in 1878, in Zagreb. Three divisions and frontmen of Zagreb Sokol demosntrated exercises on horizontal bar, parallel bars and on the vault. Three members from Varaždin, eight from Ljubljana and thirty from Zagreb performed (*Sokol*, 1878: 7: 49).

Competition was held in disciplines of vault and horizontal bar. Prizes were given for success in both disciplines combined and for each individually. 16 competitors were registered for the vault. Length and aesthetics of the jump were graded. After two jumps, the winners were Širer from Zagreb and Gunther from Ljubljana (*Sokol*, 1878: 7: 50).

Ten competitors performed on the horizontal bar. Kališnik and Gunther from Ljubljana and Kepach from Zagreb were the most successful. Judges were Ivan Kosirnik, F. Mulaček and T. Wickerhauser. With the total score from both disciplines combined (Table 1), Gunther from

Ljubljana was first, Birnbaum from Zagreb second and Kališnik from Ljubljana third. At the end of the competition, prizes were given for both disciplines. Frontmen of Zagreb Sokol did not compete, because they acted as judges (*Sokol,* 1878: 7: 51).

Table 1
Results of the interurban competition in vault and horizontal bar.

Name	country	Vault	Horizontal bar
1. Josip Gunther	Ljubljana	19,5	17
2. Birnbaum	Zagreb	17,5	14
3. Josip Kališnik	Ljubljana		19
4. Širer	Zagreb	19,5	
5. Kiepach	Zagreb		17
6. Majcen	Zagreb	17,5	
7. Hojnig	Zagreb		15
8. Stjepan Sekanović	Varaždin	15,5	

AN ATTEMPT IN CREATING SOKOL ASSOCIATION

Zagreb Croatian Sokol was connected with other Croatian societies: volunteer firefighters in Zagreb, Osijek, Karlovac and Sisak, singing societies Kolo from Zagreb, Danica from Sisak, Zora from Karlovac, Jeka Samobor and Vila from Varaždin. Principal of Croatian Sokol Josip Fon wanted to unite Sokol and firefighter societies into an association. For that purpose, a meeting in Zagreb was arranged on the second day of the competition (Bučar, 1925: 24).

Both Croatian and Slovenian Sokol societies participated in the attempt of creation of Sokol association. Representatives of Varaždin Sokol: Stjepan Sekovanić, Josip Polanec and Dragutin Nilius, Ljubljana Sokol: Josip Gunther, Miroslav Hubmayer and Rudolf Rebolj, Firefighter society in Sisak: Nikola Matković and Antun Eibel, Zagreb Sokol: dr. Josip Fon, Ivan Kosirnik, dr. Šime Mazzura, Franjo Hochman and Mladen Živojnović (*Sokol,* 1878: 7: 51).

A special committee was created, and had the task of creating the rules and organising a general meeting. Fon was elected as president, and Živojinović as secretary. Regulation propositions were created by Hochman, and societies had two months to decide if they will join the association (*Sokol,* 1878: 7: 52).

In an extraordinary general meeting of Strengthening Society Croatian Sokol, regulations propositions were accepted unanimously. Nine representative members were elected. Because of the pressure of government on Ljubljana Sokol, the association did not form (*Sokol,* 1878: 8: 57).

Zagreb Croatian Sokol was exceptionally active in conducting exercises and Sokol celebrations. On the first ball, which was held on 11th of January in 1879 in the spaces of Zagreb shooting range, music was played by the military regiment of archduke Salvatore, and in the same location, the first masquerade ball was held on 15th of February. Masquerade was accompanied by military music and organ. Czech Beseda was performed for the first

time, with 12 pairs, who were trained by Hochman. (Bučar, 1925: 26).

Zadar Official Gazzette published a notification: *A gymnastic society has been formed between youth*. At the start of summer, the society has performed a first public performance in the theatre Manzin, for humanitarian purposes. The exercises were led by Borelli, and the audience greeted the performance with excitement. Members conducted exercises with staves, sabres, on parallel bars and horizontal bar (Marić - Meštrović, 2013: 70).

In 1880, the society had conducted multiple visits to societies in other places, with the most significant being on 27th of June in Ljubljana. Members from Zagreb were greeted by singers of Slovenian Sokol and Čitalnica. After the banquet, which was held in the saloon of Čitalnica, a public exercise of Croatian and Slovenian Sokol was held in the Kozler garden. The exercise started with a simple circle dance, which was performed by 20 members from Zagreb and 20 members from Ljubljana. Afterwards, the hosts conducted simple exercises with bats and on a gymnastic horse, while members from Zagreb exercised on parallel bars with one exchange with members from Ljubljana performing on the table. Afterwards, all exercisers conducted freestyle exercises on parallel bars (Bučar, 1925:31-32).

A great earthquake happened in Zagreb on 9th of November. Several aftershocks of lesser intensity followed. 185 tremors were measured after those events. Work done by members of Croatian Sokol was significantly slowed (Bučar, 1925: 33).

On the 16th of July in 1881, society in Zadar was renamed into **Gymnastics and Fencing Society (Società di Ginnastica e Scherma**), where youth gathered regardless of nationality. On the 22nd of July, governorship approved societies regulations. Exercises were performed in arena Manzin (Marić - Meštrović, 2013: 70).

Croatian Sokol was drawing increasing attention on activities it conducted. During the celebration of the twentieth anniversary of singing society *Kolo,* which was held on 27th, 28th and 29th of May in 1882, Croatian Sokol accomodated Ljubljana Sokol, and together they performed a public exercise. Representatives of Gymnastics singing society "*Savinski Soko*l" from Mozirje and Gymnastics society "*Sokol*" from Ljubljana were guests of *Kolo*. (Zeininger, 1892: 81).

Members of Zagreb and Ljubljana societies performed a public a exercise on a hillside in Maksimir. Members from Ljubljana performed a circle dance, pommel horse exercises and exercises on horizontal bar. Members from Zagreb performed simple exercises, exercises with staves, and on rings (Bučar, 1925: 43).

ZAGREB REPRESENTATIVES ON THE 1ST CZECH PUBLIC EXERCISE IN PRAGUE

In honor of twentieth anniversary of Prague Sokol, first Czech International Sokol exercise. Guests from USA, Vienna, Ljubljana and Zagreb participated in the procession. Almost 700 exercisers performed in simple exercises on the public exercise. Afterwards, 40 divisions performed in exercises on apparatus along with 74 frontmen in six divisions (Bučar, 1925: 46).

A 7 member delegation of Croatian Sokol, under the leadership of Franjo Hochman attended the celebration. It consisted of: principal Josip Fon, leader Franjo Hochman, standard bearer Žiga Štagl and council representatives Milan Lenuci, Vaclav (Viet) Anton, Levin (Lujo) Schloosser-Klekovski and Jul. Supanek (Bučar, 1925: 45).

During the year of 1882, Varaždin Sokol was reorganized. On a special general meeting, which was held on 28th of August, society is constituted again, by electing: Pump as president, Stjepan Sekovanić as vice president, Josip Polanc as treasurer, Gjuro Horvat as recording secretary, Škender Blašković as secretary, Albert Polc, Lj. Koroskeny and Antun Goger as

councillors. One of the more significant manifestations was a public exercise conducted on 8th of September in Graberje, where eight exercisers performed on the horizontal bar and pommel horse. By the end of the year, society had 80 regular and 45 backing members, along with 9 elected councillors (Svoboda, 1923: 16-17).

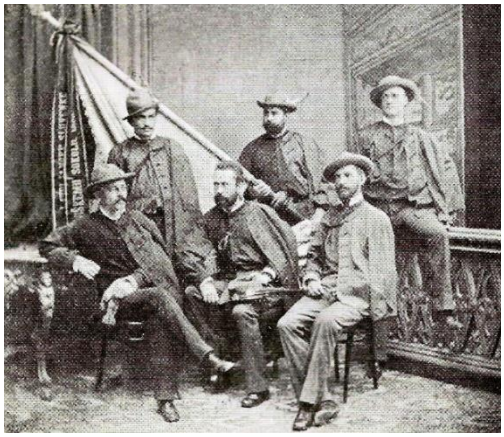


Figure 5. Representatives of Croatian Sokol on celebration of twentieth anniversary of Prague Sokol in Prague in 1882. From top left: Levin Schloosser-Klekovski, Žiga Štagl, Vaclav Anton; sitting: Franjo Hochman, Josip Fon i Milan Lenuci. *(Croatian sports museum).*

The *Officiall Gazette* holds an information of an existence of Croatian Sokol society in Trieste, with Đuro Vučković as president. There was a general yearly meeting in 1883, with Andrija Longino, Matija Trinajstić, Franjo Kevesić, Franjo Sakser, Franjo Cokelj, Ivan Inamo, Martin Krže i Hinko Paternost being elected as board members. The society had 100 members (NN, 1883: 14).

SOKOL BUILDING IN ZAGREB

Zagreb Croatian Sokol held a 9th regular general meeting, with 83 members present, on the 30th of April in 1883. Changes in regulations were the main theme of the meeting, as a result of construction of a new building, more precisely, the loan needed for the construction. As a quarter of needed members was not present, a decision was made that needed majority of the members accept the decision subsequently, with their signatures. According to the new regulations, administrative board was elected on the period of three years (Car, 1904: 2: 20).

With the acquired loans and contributions from respected members of the society, Croatian Sokol started with construction of the Sokol building. Preparational work which was led by Fordo Sejskal, began on 3rd of May, with the foundation stone laid on 10th of June. It was commemorated by Zagreb societies *Kolo*, *Sloga* and *Lira*, along with firefighter volunteers from Zagreb and fanfare (Car, 1904: 3: *36*).

Central part of the building was finished on 24th of November, in only six and a half months of time. It was constructed according to the project of Aleksander Seć and Ferdinand Kondrat. Construction was supervised by Ferdo Stejskal. Multiple contractors took part in the construction: carpenters, locksmiths and foreign contractors. Stone blocks were acquired by Hermann Ehrlich, bricks by Franjo Kondrat. At that time, the Sokol building was the largest gymnasium in Zagreb (Car, 1904: 3: 36).

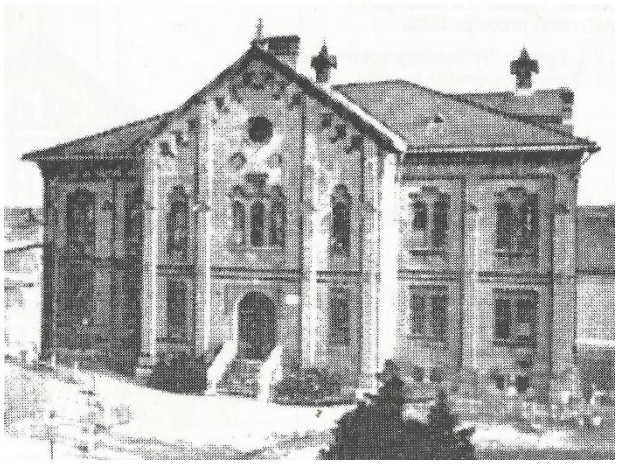


Figure 6. Croatian Sokol building in 1883

On 9th of March in 1884, executive members organised a first public exercise in the Croatian Sokol building in Zagreb. Accompanied by orchestral music, exercises performed various dancing figures, circle dancing, cartwheels and other rhythmic-dance elements. They were followed by exercises on gymnastic horse, rings, pole climbing, vault, parallel bars and pommel horse, all of them executed with high skill. Final exercises were performed on the table and horizontal bar, executed by the best exercisers: Hanuš, Hoinik, Milec, Mašek Jr., Reich, Roje Jr. And Šoštarić (Bučar, 1925: 57-58).

Governing board of Croatian Sokol in Zagreb decided to implement a type of exercise *lady and the mister* on 6th of June in 1884. It was conducted by Franjo Hochman, with Josip Hanuš as a substitute. During the female classes, entrance was forbidden for men. Over the year, 880 members participated in exercises, led by frontmen: František Hochman, Josip Hanuš, Herman Hojnig, Koloman Milec, Hrnčić and Dragutin Šoštarić, and substitutes Sertić, Mosković and Derkos (Car, 1904: 3: 37).

FOUNDATION OF NEW SOCIETIES

New gymnastic societies have been initiated in Dalmatia, middle Croatia and Slavonia. Excursions and exercises were organised by members from Zagreb, followed by creation of gymnastic societies in various places. With initiative of M. Rajs and M. Alušić, a new gymnastic society was formed in Bjelovar. On the 5th of October of 1884, Croatian Sokol in Bjelovar submitted a plea, an annex of regulations on 26th of November, being approved on 11th of December (Radan, 1973: 16: 1455).

Board of Croatian Sokol in Zagreb decided to give five of the apparatus to society in Bjelovar for half of regular price: parallel bars, gymnastic horse, table, vault and rings (Bučar, 1925: 61).

On 24th of August in 1884, Italian minority started the **Gymnastic and Fencing society in Split** (**Societa di ginnastica e scherma**). The society was formed on the initiative of youth, after the authorities approved the legislature and regulations of the society, which anticipated more sections, but the activities were mostly limited to gymnastics. First administrative board consisted of: president Dujam Savo, vice president Stjepan Foretić, treasurer Jakov Bemporath and supervisors: Josip Gabrijeli, Antun Invernizzi, Henrik Pedezzoli and Dino de Rosignoli, while the duty of gymnastics teacher was conducted by Artur Bonavia (Marović, 1990: 46).

On the 12th of April in 1885, **Gymnastic Sokol Society** was formed in Zadar. After the Dalmatian government in Zadar verified regulations of the society, first general meeting was held on 23rd of May. Hubert Borelli Vranski was elected as

president, and Petar (Pero) Klaić, Vicko Danilo, Dragutin Kopani, Niko Večeralo, as board members. Manfred Hugo, Alfons, Gagliuffi, Babić and Ante Ströll were actively involved in activities of the society (Klanac, 1995: 104: 16).

On initiative of youth, a temporay board for creation of a new gymnastic society was formed on the 24th of June, in Karlovac. President of the temporary board, Ljudevit Harazin assembled a first general meeting on the 5th of July (*Svjetlo*, 1885: 51).

Although faced with problems, Karlovac Sokol started to develop. As social opportunities were not idle, various problems occurred, and many members of the board resigned. New administrative board was constituted, and new members were elected: Ljudevit Harazin as president, Vjekoslav Gvozdanović as vice president, Pavo Pavešić as secretary, Simeon Sladoević as treasurer, and Aleksandar Bahorić as technical manager (Bučar, 1928: 2: 59).

CROATIAN SOKOL IN LJUBLJANA

Gymnastic societies in cities other than Zagreb had a problem that they were created, operated for some time and faded out of existence. Through consistent work and success, Croatian Sokol in Zagreb motivated other cities in Croatia to partake in creation of gymnastic societies. Governing board sent out a letter to all Sokol societies in Croatia and Slavonia, to support, morally and financially, the newspaper *Sokol* in Prague, which had the ability to publish discussions and reports on Croatian language. A new general meeting was held on 29th of April in 1888, with 32 members present. There was a proposal that the society should organise field trips to smaller cities as much as possible, and interest local citizens to create new gymnastic societies. Gymnastics for women, which almost discontinued over time because response was not great, was initiated once more (*Sokol*, 1904: 4: 67).

On celebration of the 24th anniversary of Sokol in Ljubljana, which was help on the 8th and 9th of September, a public exercise coupled with a competition was conducted. More than 400 members from 20 Czech, 5 Slovenian and two Croatian societies performed. Croatia was represented by 24 members from Zagreb and 15 members from Karlovac (*Sokol*, 1904: 4: 68).

7 exercisers from Czech, 6 from Slovenia, 6 from Karlovac and 4 from Zagreb competed in disciplines of vault and horizontal bar. Horizontal bar competition consisted of 2 prescribed exercises and a freestyle exercise. Competitors who could not finish the qualification exercise were disqualified from further competition. Franjo Vitauš stood out with his performance and scores. Other competitors from Zagreb were Stevo Popović, Mil. Novak and V. Mosković. Competitors from Karlovac were Ivan Prpić, Ljudevit Nehrony, Ivan Abzac, N. Bahorić, S. Cvetušić and Nikola Winterhalter (Murnik, 1973: 14: 1273-1278).

PERFORMANCE OF CROATIAN SOKOL IN PARIZ

In the beginning of 1889, Croatian Sokol in Zagreb had 255 members. Frontmen division was led by: leader Franjo Hochman, substitute leader Josip Hanuš, secretary Hinko Mašek Bosnodolski, treasurer M. Pilar, Herman Hojnig, Mosković, Milec, Milan Novak, Dragutin Hinterhuber, Srećko Bošnjaković, Žepić and Zeininger. On the th of May, a public exercise with a competition for a scholarship for a trip to Paris was organised. 34 executive members competed, with the best being Milec and Novak (*Sokol*, 1904: 4: 68).

Figure 7. Representatives of Croatian Sokol on the celebration of anniversary of Gymnastic Federation of France in 1889. *From top left: Novak, Franjo Hochman, Koloman Milec, Hinko Mašek Bosnodolski and Martin Pilar on the floor. (Croatian Sports Museum).*

Croatian Sokol deputation from Zagreb, consisting of Hochman, Mašek, Pilar, Milec and Novak, (Figure 7) attended the anniversary celebratio of Gymnastic Federation of France in Paris on the 9th and 10th of June. They represented Croatian Sokol on a great public exercise, in which all French gymnastic societies participated, as did those from other countries (*Sokol*, 1904: 4: 68).

After preparations in Gospić, on the 21st of November, gymnastic society Lika Sokol was formed, with society regulations approved on 31st of December. M. Ferković was elected as a temporary president (Radan, 1973: 16: 1455).

Antun Gavazzi was elected as the first president, F. Grospić as vice president, Krsto Pavletić as secretary, L. Vukelić as treasurer, and N. Pavelić as leader. In the beginnings, the society had 44 members who exercised in a gymnasium loaned from the city, and had acquired all of the basic apparatus (*Gimnastika*, 1894: 2: 28).

A society for promotion of gymnastics in Senj was formed, called **Senj Sokol**, and the regulations of the society were confirmed on the 21st of June in 1890. Constitutive general meeting was held on 9th of September. Dragutin Accurti was elected as president, Zvonimir Tkalec as vice president and leader, Drago Vlahović as secretary, Papić as treasurer, Rudolf Bach and Kosta Harambašić as frontmen. Society had 24 members and leased space on Stara Cesta (*Gimnastika*, 1894: 2: 28).

Figure 8. Srijem Sokol in "Najpar garden" in Vukovar in 1889. *First row from the left: Virgila Krajčović, Stjepan Ružička, Ivan Peheim; second row: Stjepan Sedeli, Hinko Streim, Ksaver Sterl, Karl Koch; third row: Skulteti, Felix Bier, Braun, Polak, Ivo Paleček, Nikola Andrić, Ivanić; last row: Gottfried and Tišov. (Gradski muzej Vukovar).*

CROATIAN REPRESENTATIVES ON THE 2ND CZECH PUBLIC EXERCISE IN PRAGUE

On the competition held on the second Sokol meeting, which was organised on the 27th to 30th of June in 1891 in Prague, Croatian Sokol was represented by two societies and 34 members in total. Zagreb Croatian Sokol, Karlovac Sokol and Senj Sokol were represented by leaders Franjo Hochman, Franjo Bučar and frontman Franjo Stipetić. Authorities did not allow foreign Sokol societies to perform on the meeting. 5 600 foreign members in uniforms were attended, with 2 500 exercisers who performed, and 30 000 viewers. Franjo Hochman was a judge on the competitions. Croatians felt the true meaning of being a Sokol on this meeting (HSK, 1907: 108).

Another gymnastic meeting between Croatian and Slovenian Sokol was organised on the 6th of September in Zagreb. Slovenian Sokol appeared in large numbers. Sokol society from Ljubljana was led by president Hribar, from Celj by president Vrečko, From Trieste, Novo Mesto and Zagorje by president Medved. Croatian Sokol was represented by societies from Zagreb, Karlovac, Rijeka and Istria. A procession of over 200 members marched through the city. On the second day, the best exercisers performed their exercises. Zagreb Sokol performed an exercise with a division of four members, and Slovenian with a division of nine members. In the evening, Sokol members met on a celebration in spaces of *Kolo*. On the last day, all Sokol members participated on a ceremonial matinee of all singing societies. Sokol members parted on the train station, followed by sounds of Zagreb and Ljubljana Sokol marching music (*Gimnastika*, 1892: 1: 10-13).

During the year, **Podravski Sokol** was formed in Koprivnica. Most significant members of the board were: president Koloman Matačić, vice president Malančec, leader Sl. Wolf. Malančec and Kralje were frontmen of the society, and led exercises twice a week in the city school (*Gimnastika,* 1891: 2: 28).

Women gymnastics started on 15th of October in 1891 in Croatian Sokol in Zagreb. Exercises were conducted in three divisions, including simple exercises and

those on apparatus (*Gimnastika*, 1891: 3: 47).

In 1893, members of administrative board elected a new executive board: Milan Amruš as president, Halper as vice president, Car as secretary, Živojnović as treasurer and Bošnjaković as temporary manager. On the 7th and 8th of July, the society attended a Sokol celebration in Ljubljana, with 26 representatives in Sokol uniforms. Along with 9 Slovenian competitors, following members from Zagreb participated in the competition: Kosatnik, Mosković, Šenk and Mužević, who won the first place (*Sokol*, 1904: 9: 132).

Gymnastics in Croatia suffered a hard blow on 23rd of June in 1893, when Franjo Hochman, founder of gymnastics in Croatia and leader of Croatian Sokol in Zagreb died in his 43rd year of life, after suffering from an illness. (*Gimnastika*, 1893: 7: 97-100).

Zagreb gymnastics came to a stop after his death. Isidor Kršnjavi used the event as an alibi to separate schools from the influence of Sokol organisation. By the order of government, on the 2nd of August, gymnastic exercises were halted in Zagreb high schools, and the sum of 2000 forints which Croatian Sokol in Zagreb received as a reparation for the use of gymnasium and apparattus, lighting, heating and teachers who conducted classes, was cancelled. It was a hard blow to the society which was a carrier of Sokol ideology in whole Croatia, Dalmatia and Slavonia (*Sokol*, 1904: 9: 131).

NEW GYMNASTIC SOCIETIES

Although the creation of Sokol in Split started significantly earlier, due to efforts of Ivan Mangjer, a constitutional general meeting was finally held. Secretary of the founding board, Josip Smodlak, managed a record of the general meeting held on the 26th of January in 1893 in the places of singing society Zvonimir. 47 executive members, 8 founding members and 53 regular members were present. Gymnastic society Croatian Sokol in Split was finally founded. (Kučić, 1994: 101: 36).

Management was eleceted, led by president Vice Katalinić and board members: regent Eduard Grgić, perfect Mate Jankov, secretary Josip Smodlaka and treasurer Ante Trumbić. The society resided in leased spaces in the basement of Diocletian's Palace. Gymnastic apparatus was procured from a facotry in Gradac (*Gimnastika*, 1893: 3: 37).

Figure 9. Exercisers of Sokol in Split on summer training grounds in 1893. (Robert Kučić)

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On the 21st of January in 1894, Croatian Sokol in Makarska was created. 43 founding members were registered, and seed capital was collected. First president was Josip rančić (Hrstić, 2011: 84). Seven days later, regulations were composed and

submitted to the regency for acknowledgment. Regulations approval, signed by the regent, arrived on 8th of April (Pravila, 1894).

Founding general meeting of Sokol in Brod was held on 30th of March in 1894. Otto Popović was elected president and Franjo Strgar as secretary. Board consisted of S. Matievć, Drag. Radosavljević and nine more members. Amendment of regulations was requested on 29th of April (Radan, 1973: 16: 1456).

On the 30th of April, Croatian Sokol in Krapina was founded. Rudolf Seissel was elected as president, Franjo Bedenko as secretary and Josip Krsnik as treasurer. On 10th of October, amendment of regulations was requested (Radan, 1973: 16: 1456).

Under the chairmanship of the new president of Croatian Sokol in Zagreb Julio Halper, 19th general meeting was held, with 32 members present. As the number of members was only 793 at the time, it was agreed that the member count should be increased. On 5th of August, 34 members of the society attended a celebration in Postojna, along with Czech and Slovenian Sokol members. After the event, Hyanek, a new teacher was employed. On the 5th of September, an emergency general meeting was called for. A repayment of loan of 34 000 forints through 37 years was agreed (Car, 1904: 9: 174).

During the year, Gymnastics Union (Torna-egylet) was formed in Čakovec. Gymnastic teacher and leader of union was Imre Gaál (Gal), and left the position shortly. Elemér Nagy became the union leader. Mihaly Dékany became the new gymnastic teacher (Zrinyi, 2005: 272).

IMPLEMENTATION OF GYMNASTICS TEACHER COURSE

Gymnastics teacher course, (Figure 10) for implementation of the Swedish gymnastic system and modern sports, under the leadership of Franjo Bučar, was held from the 1st of October in 1894, to 1st of April in 1896 in Zagreb (Bučar, 1896: 6).

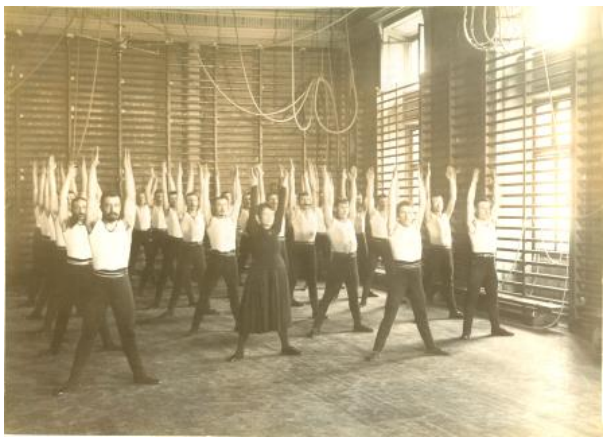

Figure 10. Warm up exercises for attendants of the course in a gymnasium. (Sl. Vaso Margetić, (Croatian School Museum Zagreb, Mf 121).

Lectures consisted of 16 classes which were significant for gymnastics: gymnastics, gymnastics history, gymnastics seminars, practical exercises in gymnastics for high school students, lessons in military gymnastics, anatomy, physiology, various winter sports, school hygiene, first aid, firefighting, swimming and dancing. Key lecturers were: Franjo Bučar, Dragutin Mašek, Hinko pl. Hranilović, August Piazza, Mirko Kolarić, Ferdo Huterer and Pietro Coronelli (Bučar, 1896: 6-7).

PERFORMANCE ON THE 3RD PUBLIC EXERCISE IN PRAGUE

From 28th to 30th June in 1885, Croatian Sokol in Zagreb attended the 3rd Sokol public exercise in Prague, with 36 representatives. Zagreb Sokol was led by Franjo bučar and Anton Hyanek. On the competition of lower division, competitors from Zagreb won tenth place, with six competitors being awarded diplomas: Hyánek, Trstenjak, Jambrišek, Šulce, Kasvalder and Fezerinac. On the competition of higher division, Radoslav Mužević won a diploma (*Gimnastika*, 1895: 9: 144).

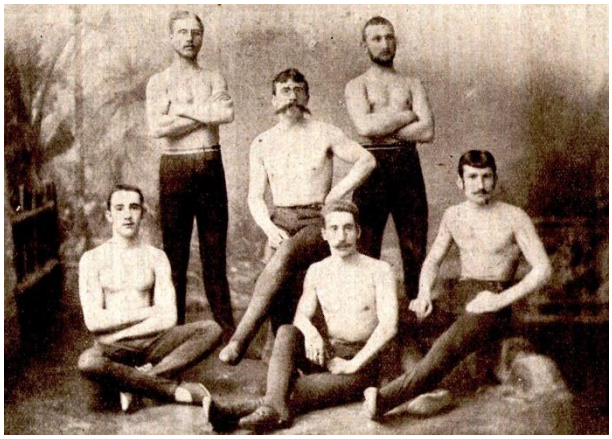

Figure 11. Frontmen of Croatian Sokol in Prague. *From forward left: Fezerinac, Kasswalder, Šulce. Back row: Trstenjak, Hyanek i Jambrišak*

First Croatian Sokol in Chicago was founded on the 12th of January in 1896 in USA. On the first general meeting Matrin Polić (son of Nikola Polić, editor of *Chicago*, first croatian newspaper in the city) was elected as president, Marko Kazić as vice president, George K. Maljevac as secretary, Petar Mrakužić as treasurer. Members of the board were: Jovo Relić, Marijan Santić and Leopold Morgan. From the starting 15 members, the count grew to 50 members. There were attempts to create Croatian Sokol societies in other cities, sadly, they did not subsist, because of a lack of Sokol frontmen and insufficient knowledge of the idea of Sokol movement (*Gimnastika*, 1896: 3: 48).

On a general meeting on 6th of December in 1896, Osijek Croatian Sokol in the Upper city was founded. First temporary board consisted of: president Ante Pinterović, vice president Josip Kostjal pl. Živanović, secretary Rudolf Bach, treasurer Franjo Vrbljančević, apparatus custodian Mijat Klas, leader Ljudevit Sorlini and board members: Hugo Spitzer, Vladimir Virag, Dragutin Franić, K. F. Nuber, Kajetan Šeper and Markus Berger. In the beginnings, the society focused on swedish style gymnastics, rather than Sokol gymnastics (*Gimnastika*, 1897: 1: 13).

CROATIAN SOKOL MEMBERS IN BELGRADE

On the 28th of March in 1897, a Gymnastic-sports club was founded in Nova Gradiška in Slavonia, led by: president Stefan Myohl, vice president Drag. Schneider, secretary F. Neterović, treasirer I. Malius, club inventory supervisor J. Aladrović, leader Fran Galić and multiple board members. A woman division was also created. There were exercises twice a week in a private gymnasium (*Gimnastika*, 1897: 7: 111).

On the 9th of May, Đuro Gavrilović called interested citizens to attend a meeting in the city hall in Zemun, to initiate Zemun

Sokol. On the initiative general meeting a board was elected: president Marković and members M. Zdelar, M. Steinlechner, A. Mariček and Đuro Gavrilović. The society began exercising in a dance hall of the hotel "Central". The board held two general meetings, prepared regulations, and then held another general meeting, where the new regulations were adopted (*Gimnastika*, 1897: 8: 124-125).

On the 11th of June, Croatian Sokol from Zagreb attended an event in Belgrade. Led by vice president Stjepan Mlinarić, 22 members attended the event. On the second day, a public competition was held in the Upper city in the fortress. Members from Zagreb that competed were: Haynek, Šenk, Trstenjak, Fezerinac, Nehroni and Kos. A division of eight members performed exercises on the pommel horse, parallel bars, horizontal bar and vault. A public exercise was held on the evening of the last day, with king, queen and members of Serbian government in the audience (Car, 1904: 12: 37-38).

Figure 12. Croatian Sokol in Zagreb on the consecration of the flag of gymnastic society *Dušan Silni* in Belegrade in 1897.

Franjo Bučar was invited on an Olympic congress, which was held from 23rd of July to 2nd of August in Le Havre. Bučar could not attend the congress, because of the poor financial situation. Croatian Sokol in Zagreb and Croatian Cycling Federation authorised Jiřij Guthom from Prague to represent them on the Olympic congress (Jajčević, 2007: 14-15).

On the 24th of September in 1897, 30 patriots met in Čitaonica in Pula, and founded First Istrian Sokol in Pula (Naša sloga, 1898: 2). After small adjustments in regulations, they were confirmed on the 21st of November, from high regency in Trieste. First regular general meeting was conducted on 8th of December. Elected temporary board gave a notice that the biggest and most beautiful gymnasium in Pula, "Stadt Pola" was acquired for the purpose of conducting exercises. President Lacko Križ, vice president Ante Mezulić, secretary Stijepo Gjivić and treasurer Al. Kandušer were elected into the first board (Naša sloga, 1905: 14).

Influence of other gymnastic societies led to creation of a new society in Šibenik. It was founded on 6th of August in 1889, under the nam Sokol in Šibenik. The board consisted of: president Filip Smolčić, vice president Mate Živković, secretary Ivan Marković and treasurer Vladimir Kulić. Marko Stojić became the leader, Niko Blažević and Josip Tambača frontmen. A count of 66 members was achieved (*Gimnastika*, 1899: 12: 143).

At the start of 20th century, majority of gymnastic societies are working with lesser intensity. Majority of the societies are

dormant except in Zagreb and in lesser extent in Dalmatia.

CROATIANS ON THE 4TH PUBLIC EXERCISE IN PRAGUE

From 28th of June to 1st of July in 1901, 4th Czech Sokol public exercise in Prague was held. Czech and other Slavic Sokol attended, along with French and Danish exercisers. 571 society, counting 11 000 members participated in the event. 860 women and 1988 youth members participated. 40 Croatian members participated in the event. Croatian Sokol members from Zagreb, along with one member from Senj were led by Lazar Car (Sokol, 1903: 10: 122-123).

Competition was held in disciplines of horizontal bar, parallel bars, pommel horse, rings and vault. Members from Zagreb competed in 2nd division, and with 202,5 points, won the 3rd prize. For the Zagreb division, following members competed: division leader Dragutin Šulce, Ferdo Fezerinac, Ivan Dončević, Stjepan Kravnik, Vladimir Maček, Dragutin Retl and substitute Mirko Kos. As individuals, following members competed: Šulce who won the first prize and Fezerinac who won the third prize (Sokol, 1903: 10: 124-125).

Osijek started to become a major center of gymnastic activities in eastern Croatia. On 26th of May in 1901, representatives of the 1st Istrian Sokol from Pula, under the leadership of Lacko Križ, of the Croatian Sokol from Split, led by Rikard Katalinić-Jeretov, of the Croatian Sokol fom Zagreb, led by Juraj Vrabanić, and a representative of Croatian Sokol from Zadar, arrived in Osijek. They attended the ceremonial consecration of the flag of singing society *Lipa* from Osijek. On the public celebration in the City gardens, 40 members from Osijek and Zagreb performed simple exercises, followed by exercisers on apparatus. A great ball was held in the evening, for all Sokol members. On the second day, on the morning matinee, Sokol members from Split performed Moreška(Bučar, 1929: 12: 545).

On the initiative of patriots from Drniš, on the 28th of August, a cultural-sports society Croatian Sokol in Drniš, was created. Majority of founding members were musicians. For some time, the exercises were conducted in the yard and magazine of a trader Mićo Nakić – Vojnović (Sokol, 1903: 12: 146).

Sokol for Opatija and Volosko was also founded during the year. Members of the society prepared special events and exercises during celebrations and holidays, and frequently held public exercises on Sundays.

A first temporary board of citizens of Sisak was organised, with a purpose of founding of a new society in Sisak. On 23rd of February in 1902, a founding general meeting of Croatian Sokol in Sisak was held. The society played a major role in the social life of Sisak. President Benjamin Šuperina, vice president Matija Sigur, treasurer Ferdo Gurski, secretary and leader M. Latković were elected. Regulations of the society were confirmed on 21st of May. Soon, the society had fifteen members exercising (Sokol, 1903: 11: 141-142).

Figure 13. Frontmen of Croatian Sokol in Zagreb in 1902. (Croatian Sports Museum).

On the 17th of June in 1902, Croatians in Mostar founded a society under the name Herzegovian Gymnastic Sokol in Mostar. An administrative board was elected: president Dragutin Kohler, vice president Janko Ašperger, secretary Cesar Vlajo, treasurer Marko Glavina and gymnastic president Toma Pališa (Sokol, 1903: 5: 56).

Sokol and gymnastic ideas have been well understood and over the year an increasing number of societies developed their work throughout middle Croatia, Slavonia, Dalmatia, Bosnia and Herzegovina and Istria. Sokol societies have expanded and existed in: Zagreb, Osijek, Varaždin, Sisak, Karlovac, Gospić, Senj, Vukovar, Zadar, Split, Šibenik, Sarajevo, Mostar, Volosko and Pula (Sokol, 1903: 1: 8).

A specialised magazine was created for easier access to news and new exercises of Croatian Sokol societies. *Sokol*, a magazine of Croatian and Slovenian Sokol movement, started being published on 15th of January in 1903, with the main editor being Franjo Bučar. Front page of the magazine depicts unity of Croatian and Slovenian Sokol societies. Croatian and Slovenian crests are positioned in the middle, with crests of Slavonia, Dalmatia, Bosnia and Herzegovina and Istria to the left, and crests of Štajerska, Koruška, Gorica and Trieste to the right (Sokol, 1903: 1: 1).

Figure 14. Administration of the First Istrian Sokol in Pula in 1903. (Historical and Nautical Museum of Istria, PPMI-37970).

Delegations of Croatian Sokol societies organised a meeting on 28th of June in 1903 in Zagreb, for an agreement about major common issues of joint performances, collaboration and possible merger. Hanuš, Švarc, Hirt, Bučar, Car and

Vrbanić from Zagreb, Skarpa from Senj, Zima from Varaždin and Fezerinac from Pula, were present at the meeting. Car represented Drniš, Vrbanić represented Makarska, while societies from Split, Sisak and Karlovac apologised for being unable to participate in the meeting (Sokol, 1903: 7: 87).

There was a discussion about regulations, methods of organization, manners of publishing the magazine Sokol, courses for Sokol frontmen and teachers, lectures based on the Sokol idea, manner of work in each society, various sports activities in societies, Sokol division, dicipline in public exercises, records of statistics of members, means of field trip organization, flag design and various other details (Sokol, 1903: 7: 88-89).

In the Polish city Lavov, from the 27th to 30th of June, a Polish Sokol public exercise was organised. Zagreb Sokol was represented by Franjo Bučar, secretary Lazar Car and teacher Šulc with six exercisers. Pula Sokol was represented by Fezerinac, and Senj Sokol was represented by Scarpa. Sokol from Karlovac was represented by: president Božo Vinković, vice president Janko Modrušan, secretary Ivo Badovinac and total of 11 members (Sokol, 1903: 8: 77). Croatian divison, comprised of members from Zagreb and one member from Pula competed on the competition along with 25 Polish and 28 Czech division. Croatians displayed a good practice in exercises on pommel horse, horizontal bar and parallel bars, and were rewarded (Sokol, 1903: 9: 105).

Figure 15. Croatian Sokol from Makarska in Metković, on the 26th of July in 1903. (Makarska City Museum, GMM, F-1759c).

On the 23rd of August,Croatian Sokol in Drniš prepared a major public exercises, which involved other Croatian societies from that region. Along with the hosts, members of Sokol societies from Split, Makarska, Šibenik and Zadar were present. Procession counted 76 members from Šobenik, 40 from Makarska, 100 from Split, 58 from Drniš. There was a meeting, led by Smodlaka. It was decided that a board will be created, consisting of all leaders and presidents of Dalmatian societies (Sokol, 1903: 12: 145).

On 27th of August, Josip Linić from Trsat proposed that old regulations from the former society should be ammended, and that it should be reorganized into Sokol in Šušak, which was accepted on 27th of September in 1903, on a general meeting.

By the end of 1903, there was 16 societies, with 15 honorary, 203 founding, 1160 backing and 1622 executive members, from which more than one third exercised regularly. From all the gymnastic societies in Croatia, Zagreb Sokol was the only society that had a personal gymnasium,

while the majority of the societies practiced in school gymnasiums, and four societies owned personal summer training ground. All societies owned almost all of the apparatus, or at least the basic ones. Some of the societies conducted exercises for women (Sokol, 1904: 11: 166-168).

REFERENCES

Bučar, F. (1896). *Izvještaj tečaja za učitelje gimnastike u Zagrebu* [Report of the course for gymnastics teachers in Zagreb]. Zagreb: Tiskarski zavod Narodnih novina.

Bučar, F. (1924). *Jubilarna godina Hrvatskog sokola u Zagrebu, 2.* [Jubilee year of the Croatian Sokol in Zagreb, 2]. Hrvatski sokol, 3.

Bučar, F. (1925). *Povijest Hrvatskog Sokola, Matice u Zagrebu 1874.-1885.* [History of the Croatian Sokol, Matica in Zagreb 1874-1885]. Zagreb: Naklada Hrvatskog Sokola Wilsonovog.

Bučar, F. (1928). *Povijest Hrvatskog sokola u Karlovcu* [History of the Croatian Sokol in Karlovac]. Hrvatski sokol, 2/1928.

Bučar, F. (1929). *Povijest Hrvatskog sokola u Zagrebu* [History of the Croatian Sokol in Zagreb]. Hrvatski sokol, 12/1929.

Car, L. (1904). *Povijest Hrvatskog sokola u Zagrebu* [History of the Croatian Sokol in Zagreb]. Sokol, 2/1904.; Sokol, 3/1904.; Sokol, 9/1904.; Sokol, 12/1904.

Esseker Lokalblatt und Landbote, *58.*, Osijek, 23. srpnja 1865.

Firinger, K. (1974). *Sportska djelatnost i sportska društva u Osijeku do 1914.* [Sports activities and sports clubs in Osijek until 1914]. Povijest sporta, 19/1974.

Hajdenak, A. (1875). *Tjelovježba u pučkoj školi - Naputak za učitelje, kako metodično mogu poučavati u prostih vježbah, u koliko se one u školi izvesti dadu* [Exercise in the public school - Instruction for teachers, how to methodically teach simple exercises, how often they are performed in school]. Zagreb: troškom piščevim.

Hajdenak A., Hochman, F. (1878). *Sokol, Glasilo za tjelovježbu* [Sokol, Exercise Bulletin]. Zagreb:1878.

Hochman, F. *Gimnastika - list za školsku i družtvenu gimnastiku* [Gymnastics - magazine for school and social gymnastics]. 1/1891.; 3/1891.; 11/1891.; 1/1892.; 3/1892.; 3/1893.; 7/1893.; 1/1895.; 9/1895., 12/1899., Zagreb: Knjižara Lav. Hartmana.

Hrstić, I. (2011). Hrvatski sokol u Makarskoj (1894.-1914.) [Croatian Sokol in Makarska (1894-1914)]. Historijski zbornik, LXIV. 69,1.

Hrvatski sokolski kolendar za god. 1907. [Croatian Sokol calendar for the year 1907]. Zagreb, 1907., Franjo Bučar (ur.), Zagreb: Hrvatski sokolski savez, 1907.

Iveljić, Ž. (2012). *Tjelovježbene udruge istočne Hrvatske do 1929. godine*, [Physical exercise associations of eastern Croatia until 1929]. Vinkovci: Povijesno i športsko društvo Hrvatski sokol Vinkovci.

Iveljić, Ž. (2014). *Sto deset godina Hrvatskog gimnastičkog saveza* [One hundred and ten years of the Croatian Gymnastics Federation]. Zagreb: Hrvatski gimnastički savez.

Jajčević, Z. (2007). *Olimpizam u Hrvatskoj* [Olympism in Croatia]. Zagreb: Libera Editio.

Klanac, M. (1995). *110 obljetnica Gimnastičkog društva Sokol u Zadru* [110th anniversary of the Sokol Gymnastics Society in Zadar]. Povijest športa, 104/1995.

Kučić, R. (1994). *100 godina gimnastike u Splitu* [100 years of gymnastics in Split]. Povijest športa, 101/1994.

Marić, D., Meštrović, R. (2013). *Baština zadarskog sporta* [Heritage of Zadar sports]. Zadar: Športska zajednica Grada Zadra.

Marović, D. (1990). *Povijest sporta u Splitu, Od antičkih igara do prvog svjetskog rata* [The history of sports in Split, from the ancient games to the First World War]. Split: Savez za fizičku kulturu općine i

Samoupravna interesna zajednica fizičke kulture općine, Split.

Murnik, V. (1973). *Prva slavenska gimnastička utakmica u Ljubljani 1888. godine,* [The first Slavic gymnastics competition in Ljubljana in 1888]. Povijest sporta, Zagreb, 14., lipanj 1973.

Narodne novine [National newspapers]. Zagreb, 14, 18. siječnja 1883.

Naša sloga [Our agreement]. Trst, 2, 13. siječnja 1898.

Naša sloga [Our agreement]. Pula, 14, 2. travnja 1905.

Pravila hrvatskog družtva za tjelovježbu Srijemski sokol u Vukovaru [Rules of the Croatian association for exercise Srijemski sokol in Vukovar]. Vukovar, 17. siječnja 1886.

Pravila Makaranskog Gimnastičnog Družtva „Hrvatskog Sokola" [Rules of the Makarska Gymnastics Association "Hrvatski Sokol"]. Zadar: Brz. Kat. Hrv. Tisk., 1894.

Pravila Zagrebačkog družtva za tjelovježbu Hrvatski sokol Zagreb [Rules of the Zagreb Association for Exercise Hrvatski sokol Zagreb]. NSK, 1874.

Primorac br. 2. [Primorac no. 2nd]. Kraljevica, 6. siječnja 1875.

Radan, Ž. (1973). Zbirka pravila gimnastičkih i sportskih organizacija od 1861. do 1914. u Arhivu Hrvatske [Collection of rules of gymnastics and sports organizations from 1861 to 1914 in the Croatian Archives]. *Povijest sporta, Zagreb, 16,*1973.

Sokol – časopis Hrvatskog i slovenskog sokolstva (1903). [Sokol - magazine of Croatian and Slovenian Sokols]. Zagreb: Hrvatski sokol u Zagrebu, 1/1903.; 5/1903.; 7/1903.; 10/1903.; 11/1903.; 12/1903.

Sokol – časopis Hrvatskog sokolstva (1904). [Sokol - magazine of the Croatian Sokol Association]. Zagreb: Hrvatski sokol u Zagrebu, 4/1904.; 9/1904.; 11/1904.

Srijemski Hrvat br. 76. [Croatian from Srijem no. 76]. Vukovar, 22. rujna 1886.

Svjetlo, br. 51. [Light, no. 51]. Karlovac, 11. srpnja 1885.

Svoboda, B. (1923). *Sokolstvo u Varaždinu 1877. - 1923.* [Sokol in Varaždin 1877 – 1923]. Varaždin: Sokolsko društvo.

Švegar, Z. (2005). *Povijest karlovačke gimnastike: 1885-2005.* [History of Karlovac gymnastics: 1885-2005]. Karlovac: Gimnastički klub Sokol.

Zeininger, B. (1892). Jubilejski spis [Jubilee file]. Zagreb: Knjigotiskarski i litografijski zavod C. Albrecht.

Zrinyi, K. (2005). Monografija grada Čakovca (Ssáktornya monografiaja), Povijest dvorca i grada. [Monograph of the city of Čakovec (Ssáktornya monograph), History of the castle and the town]. Popis stanovništva iz 1901., Čakovec: Povijesno društvo Međimurske županije.

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Article received: 13.12.2022
Article accepted: 3.2.2023

A FOUR-YEAR CYCLE COMPARISON OF THE NUTRITIONAL AND CARDIOVASCULAR HEALTH STATUS OF AN ELITE-LEVEL FEMALE ARTISTIC GYMNAST: CASE STUDY REPORT FROM SLOVENIA

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Original article *DOI:15.1.27-46*

Abstract

Regular monitoring of body composition, nutrition, health, and motor skills are crucial for further training process planning and performance progress. With the same protocol and methods, we evaluated a four-year change (2018 vs. 2022) in the nutritional and cardiovascular health status of the currently most successful elite-level adult female artistic gymnast in Slovenia. Detailed body composition and dietary intake were assessed using dual-energy X-ray absorptiometry and a standardized food questionnaire FFQ. The blood lipids and safety factors, blood pressure, and serum micronutrients (e.g., B_{12}, 25-hydroxyvitamin D (25(OH)D), potassium, calcium, phosphorus, magnesium, and iron) status were measured. The four-year comparison showed an improved body composition status: decreased body fat mass/percentage, android fat percentage, and android/gynoid ratio, while other anthropometrical and body composition parameters remained essentially unchanged. We also measured an improvement of some and worsening of other cardiovascular health serum variables (i.e., decreased total cholesterol but increased low-density lipoprotein cholesterol and S-glucose), most likely due to the differences in assessed dietary intake (i.e., lower total fat, mono- and polyunsaturated fatty acid intake but higher cholesterol intake and still high free sugar and saturated fat intake, despite higher fiber). Notably, nutrient intakes that are generally of concern (fiber (borderline low intake), eicosapentaenoic omega-3 fatty acids and docosahexaenoic omega-3 fatty acids, vitamin B_{12} and D, calcium (borderline low intake), iron, and zinc) were within recommended ranges. However, the athlete's vitamin E and potassium intakes were not adequate. Furthermore, in 2018, the athlete did not consume dietary supplements, while she now regularly uses several dietary supplements, including enriched plant-based protein powder, isolated vitamin B_{12}, C, D, and iron. Moreover, the athlete had significantly lower than recommended serum levels of 25(OH)D, probably due to insufficient regular intake of vitamin D in the form of a dietary supplement (1000 IU/d). Moreover, from the micronutrient serum, phosphorus, and iron levels that deviated from the reference values in the 2018 study, in the current study, they were found to be within referenced ranges (i.e., iron status was markedly improved). This kind of screening toolbox, using valid, sensitive, and affordable methods and with rapid organizational implementation, may be a viable format for regular monitoring.

Keywords: *elite-level athlete, female, artistic gymnast, body composition, bone mineral density, nutrition, micronutrients, 25-hydroxyvitamin D, cardiovascular health.*

INTRODUCTION

Tracking changes in athletes' training, health, nutrition, performance, and recovery enables coaches, athletes, and the scientific community to understand better how a

specific sports strategy affects athletes (Lee et al., 2017; Thomas et al., 2016). Body composition and nutrition status play vital roles in monitoring the efficiency of physical adaptation to the training process and athletic performance, aimed at optimizing competitive performance potential (Ackland et al., 2012; Bacciotti et al., 2017; Dallas et al., 2017). Furthermore, nutrition is a key determinant of the effectiveness of adaptive responses to a training process, recovery, and sports performance. Moreover, it has an important, if not crucial, role in health status (Malsagova et al., 2021; Thomas et al., 2016).

Although there is not yet sufficient recent data to provide robust profiles of optimal elite-level female artistic gymnasts' body composition features (Bacciotti et al., 2017; Visscher et al., 2012), it is known that success in high-level gymnastics compared with lower competitive levels is associated on average with smaller size, lower body mass (BM) and body fat percentage (BF %) (Bacciotti et al., 2017). Part of the reason that there is not yet a consensus regarding the desired ranges of anthropometric variables and body composition components are (i) outdated data for elite-level female artistic gymnasts, (ii) limitation in comparing body composition with different assessment technologies, (iii) the problem of proper interpretation of the measured body composition status in connection with the (sub)optimal energy and general nutritional deficiency among female artistic gymnasts, (iv) the problem with uncritical use of the terms "elite-level" and "high-performance level" (i.e., there is no consensus on who belongs to which category or the use is arbitrarily, even uncritically, left to researchers), and finally, (v) various recent changes in sport gymnastics (e.g., safer apparatus, changes in Code of Points in 2006, the individual decision to compete on only one or two apparatus) (Anderson & Petrie, 2012; Bacciotti et al., 2017; Dallas et al., 2017; Jakše, Jakše, Fidler Mis, et al., 2021; Visscher et al., 2012). Consequently, physical and motor requirements and dietary requirements for elite-level female artistic gymnasts depend on these modified factors and changed circumstances, for which more current data is required.

In addition, at the elite-level, the International Olympic Committee and National Olympic Committees/National Federations are also performing, requiring, or recommending careful cardiovascular (CV) screening to avoid silent fatal abnormalities not being detected (Ljungqvist et al., 2009). Regardless, experts recommend healthy/balanced nutrition (i.e., high intake of fruits, vegetables, whole grains, and legumes, and limited quantities of lean meat (including poultry and seafood), low-fat dairy products, and liquid vegetable oils) for CV disease prevention and treatment to all populations. These recommended dietary patterns are all low in trans-fatty acids and saturated fat (SFA), sodium, free sugars, and ultra-processed foods, including refined grains (Freeman et al., 2017; Tobias & Hall, 2021).

The present case study aims to compare the investigated nutritional (i.e., anthropometric and body composition, dietary intake, and serum micronutrients measures) and CV health and safety status of an elite-level adult female artistic gymnast (very experienced in terms of competitive sports) from Slovenia with her data from the study published in 2018 (four-year period) (Jakse et al., 2019; Jakše, Jakše, Čuk, et al., 2021; Jakše, Jakše, Fidler Mis, et al., 2021). We chose the case study because only one truly elite-level female artistic gymnast from Slovenia is currently competing; therefore, the resulting changes will not be masked by the majority of female artistic gymnasts competing at a lower (e.g., high-performance) level.

METHODS

The study design, the protocol, the methods, and the ethical aspect of the 2018

study were reviewed and approved by the Slovenian Medical Ethics Committee (approval document no. 0120-177/2018). Therefore, another ethical evaluation for an identical study was not necessary. Regardless, the athlete re-signed an informed consent form for inclusion in the study before the current study was conducted. In addition, the athlete was not remunerated financially for participation in the study. However, we promised her feedback on the obtained comparative results. All the assessments in the study were funded by the authors.

Furthermore, the current study was conducted on 14 April 2022 and executed at the same location (Medical Centre Dravlje d.o.o., Ljubljana, Slovenia), using the same protocol and methods (and carried out by the same experienced physician) as the study completed in April 2018, the published data of which we used for our comparison (Jakse et al., 2019; Jakše, Jakše, Čuk, et al., 2021; Jakše, Jakše, Fidler Mis, et al., 2021). The athlete completed an online questionnaire sent to her one day before other measurements were taken (i.e., blood sample draw (i.e., 15 mL of blood for a complete biochemical assays); anthropometric and body composition measures). A blood assay was collected, and measurements were assessed after an overnight fast.

The athlete was repeatedly recruited through personal contacts. The artistic gymnast has recently made significant progress in terms of results, so we agreed to repeat the study due to our mutual interests. The studied elite-level adult athlete (age 28.9 years) was a member of the Slovenian female national artistic gymnast team and was competing in the international quality class (i.e., World Cups, European Championship, and World Championship). At the time of the study, the gymnast was ranked the highest among all national team members (FIG, 2022).

The main variables included detailed characteristics of the athlete's nutritional and CV health status. The results in the current study were compared with the obtained results from the study completed in 2018 and published (Jakse et al., 2019; Jakše, Jakše, Čuk, et al., 2021; Jakše, Jakše, Fidler Mis, et al., 2021). In addition, we will also add the results of the best elite-level artistic gymnast (AG-2) from our first study on the same apparatus (i.e., vault) (Jakse et al., 2019; Jakše, Jakše, Čuk, et al., 2021; Jakše, Jakše, Fidler Mis, et al., 2021), which we could not analyze this time due to the subject's pregnancy. Furthermore, comparable anthropometric and body composition variables of elite-level artistic gymnasts (AG-3) published by Greek researchers will be compared with our results in the same table (Dallas et al., 2016). Where body composition variables were reported as a range of measurements one week apart (i.e., BM and BF %), we took the average of the two for clarity reasons.

The detailed characteristics of the artistic gymnast (i.e., age, education, training status, and type of dietary pattern) were evaluated with the questionnaire; however, these variables were part of a standardized food frequency questionnaire (FFQ) (De Keyzer et al., 2013). In addition, the preferred competitive discipline (obtained from the athlete) and quantitative competitive level (ranking in important international competitions) are publicly available information provided by the Federation International De Gymnastique (FIG) (FIG, 2022).

The anthropometric and body composition indices included: body height (BH); BM, body mass index (BMI); BF %, android (A) and gynoid fat (G) distribution; A/G ratio; body fat mass (BFM); fat-free mass (FFM); lean soft tissue (LST); bone mineral content total (BMC total); bone mineral density total (BMD total), and BMD segmental (i.e., left femoral neck, left femur, legs, pelvis, spine, trunk, ribs, arms, and head)). (BM is the sum of BFM, LST, and BMC, while FFM is the sum of LST and BMC.)

Body height (cm) was measured using a standardized column scale (Seca 220, Seca Gmbh & Co., Hamburg, Germany), and BM (kg) was measured using a medically approved personal floor scale (Kern, MPS 200K100HM, Kern & Sohn, Balingen, Germany), whereas body composition was assessed using dual-energy X-ray absorptiometry (DEXA) (General Electric Company, model Lunar Prodigy 5, with EnCore software, version 13.31). Body mass index (kg/m²) was calculated from BH and BM. All the assessments were performed by a well-trained and experienced physician on the same DEXA model as in our study conducted in 2018 (Jakse et al., 2019; Jakše, Jakše, Čuk et al., 2021).

To assess the dietary habits of the athlete in the previous year, we used a manual technique and double-checked it to prevent potential errors: a 52-item qualitative FFQ based on a previously substantiated 50-item FFQ (De Keyzer et al., 2013) and validated on Dutch population for assessing food consumption with seven-day estimated diet records (Clarys et al., 2014). In addition, this FFQ has been used for athletes (i.e., elite-level/high-performance female swimmers and artistic gymnasts) (Jakše, Jakše, Fidler Mis, et al., 2021) and for healthy adults (Jakše, Jakše, Godnov, et al., 2021) in the Slovene population.

To evaluate dietary intake, we used the OPEN Platform for Clinical Nutrition (Korošec et al., 2013; OPKP, 2021), which is a web-based solution developed by the Jožef Stefan Institute in Slovenia. Food intake data from the FFQ were used to assess energy and nutrient intake and the frequency of food group consumption. However, it was impossible to estimate actual sodium, chloride, or iodine intake from food preparation methods (e.g., added (non) iodized salt) based on the FFQ alone, so these minerals and trace elements were shown only from the food sources as such. Importantly, FFQ does include minimally processed, processed, or ultra-processed products that include sodium (e.g., mayonnaise, butter, lard, ketchup, confectionery, canned beans, cheese, fries, commercial bread, and pastries) (Monteiro et al., 2019); however, the intake of these foods is usually lower in athletes compared with the general population. In addition, the FFQ included dietary supplementation and sports drink, specifically the name of the manufacturer, the amount of intake, and the frequency of consumption, thus capturing the athlete's actual dietary intake. Furthermore, we could also precisely distinguish free sugars from total sugar, and plant-based and animal-based protein from total protein intake by using the unique FFQ and OPEN system. Finally, folic acid from supplementation to folate conversion factor was used: 0.5 μg of folic acid = 1 μg of folate (Institute of Medicine, 1998).

Data regarding the dietary intake of the athlete was calculated, expressed as kcal/d (energy), in units/d (i.e., in g/d (macronutrients), except for dietary cholesterol (mg/d), water intake (L/d), and micronutrients (mg/d and μg/d)) and percentage of daily energy intake (macronutrients).

Finally, the intake of energy and nutrients intake of greater importance or concern (i.e., vitamin B_{12}, D, eicosapentaenoic omega-3 fatty acids (EPA) and docosahexaenoic omega-3 fatty acids (DHA), calcium, and iron) or nutrients that were consumed inadequately/in excess were compared with the reference values for energy and nutrient intake issued by the National Institute of Public Health of Slovenia (National institute of Public Health of Slovenia, 2020); values are summarized according to the recommendations of Central European (German (D), Austrian (A), and Swiss (CH) (D-A-CH)) reference values (DGE/ÖGE/SGE, 2018). Unfortunately, Slovenian recommendations do not mention the reference values for free sugar, saturated fatty acids (SFAs), poly- and monounsaturated fatty acids (PUFAs and MUFAs), cholesterol, EPA and DHA, and

biotin intake; therefore, the athlete's free sugar intake was compared with the SACN recommendation (< 5% of daily energy intake) (Scientific Advisory Committee on Nutrition, 2015), SFA, PUFA, MUFA, cholesterol, and biotin intake was compared with the D-A-CH reference (DGE/ÖGE/SGE, 2018; Jungert et al., 2020, 2022), and EPA and DHA intake with the Dietary Reference Values of the European Food Safety Authority (EFSA, 2017). Additionally, water intake from solid foods, beverages, and supplementation (i.e., sports drinks and carbohydrate powder mixed with water) was evaluated. Total water intake was not compared with the guidelines since it depends on the sport, the type of exercise, and the environment (Thomas et al., 2016). Furthermore, the carbohydrates intake was compared with the joint position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine for nutrition and athletic performance (Thomas et al., 2016). The variable was not calculated in terms of energy availability (EA) due to our inability to estimate energy expenditure properly or obtain accurate information.

Frequently monitored serum micronutrients that are of concern among athletes were assessed and included in the analysis. The following were analyzed: vitamins B_{12} (S-vit B_{12}) and 25(OH)D), calcium (S-Ca), magnesium (S-Mg), phosphorus (S-P), and potassium (S-K), and trace element iron (S-Fe).

For the micronutrients, the abovementioned medical center used the same manufacturer and methodology as in our 2018 study (Jakse et al., 2019; Jakše, Jakše, Fidler Mis, et al., 2021). The obtained results from both studies were compared with the 2018 study and with the following references: for S-vit B_{12} with the reference value suggested to prevent neurocognitive disorders late in life (Wolters et al., 2004). For 25(OH)D status, three categories were used (i.e., sufficiency: > 75 nmol/L, insufficiency: 50 –75 nmol/L, and deficiency: < 50 nmol/L) (Holick, 2009). Reference concentrations of serum minerals and trace elements used are from the University Medical Centre Ljubljana, Slovenia, the national laboratory (University Medical Centre Ljubljana, 2018).

The assessed CV diseases risk factors, i.e., total cholesterol (S-cholesterol), high-density lipoprotein (HDL cholesterol), low-density lipoprotein (LDL cholesterol), and triglycerides were measured directly, as was blood pressure (BP). The safety markers in the blood analysis included uric acid (S-UA), fasting glucose (S-glucose), and hemoglobin. For biochemical analyses, we used the same protocol, manufacturer, and methodology as in our 2018 study (Jakše, Jakše, Fidler Mis, et al., 2021).

To assess cardiovascular health, the values obtained were compared with the recommended targets for cardiovascular disease prevention by the European Society of Cardiology (Visseren et al., 2021). For S-cholesterol and HDL cholesterol reference values, the reference values from the national laboratory, the University Medical Centre Ljubljana, Slovenia, were used (University Medical Centre Ljubljana, 2018). S-glucose recommendations from the European Diabetes Epidemiology Group for lean adults (BMI < 25 kg/m²) were used (Borch-Johnsen, 1999). For S-UA, a consensual threshold was used for all healthy subjects (Desideri et al., 2014). For hemoglobin, we used recommended cut-offs for a non-anemic state from the World Health Organization for non-pregnant females (> 120 g/L) (WHO, 2011).

The current study is a case study report of one elite-level adult athlete and compares the results obtained with the results for the same athlete from a study four years ago (Jakse et al., 2019; Jakše, Jakše, Čuk, et al., 2021; Jakše, Jakše, Fidler Mis, et al., 2021); therefore, only descriptive statistics are used to present the results.

RESULTS

The athlete started with gymnastics at the age of four and is currently competing on the vault and on the balance beam, and (if needed for the purpose of all-round competition) also on the floor and on the parallel bar. By far, she is the most successful on the vault. The ranking in important international competitions (FIG, 2022) is presented in Table 1.

Furthermore, during the studied (competitive) period, the athlete had on average 18–20 hours of training per week. In addition, the athlete reported to have regular menstrual status; however, she also reported extraordinary pain during the menstrual phase that lasted 7–10 days. However, the athlete continued the training process smoothly, even during the menstrual phase. In addition, it is essential to emphasize that the athlete maintained the same overall dietary pattern as in the 2018 study (i.e., an omnivorous diet).

Table 2 shows the changes in anthropometrical and body composition parameters. The athlete markedly changed some of her body composition variables in terms of decreased BFM (-1 kg (11%)), android fat (-3.7% (35%)), and A/G ratio (-0.12 (36%)). However, other anthropometrical and body composition parameters remained relatively unchanged

A comparison between the athlete's daily energy and nutrient intakes is presented in Table 3 and Table 4. The macronutrient composition of the food intake was 30% fat, 47% carbohydrate, 3% fiber, and 20% protein. The estimated carbohydrate intake of the athlete (4.3 g/kg BM/d) was within the recommended 3–5 g/kg BM/d guidelines for low intensity (skilled-based) physical activity (Thomas et al., 2016).

Furthermore, the obtained results showed that the athlete in this study, compared with the 2018 study, increased their carbohydrate intake and decreased the fat intake (i.e., total fat, SFA (% E), MUFA, and PUFA), increased EPA and DHA, cholesterol, and protein intake (i.e., from plant proteins (e.g., mostly due to plant-based protein dietary supplement) and also animal proteins (e.g., from milk, fish, chicken, and eggs)). In addition, the fiber intake markedly increased but was still not adequate (27 g/d vs. 30 g/d, as recommended). Significantly, in the current study, the athlete consumed adequate EPA and DHA (442 mg/d vs. 250 mg/d, set as reference) (EFSA, 2017), where the athlete's EPA and DHA intake were all from food sources.

Micronutrients that are often of concern in the general population and among athletes, such as vitamin B_{12} (58 μg/d, the reference is set to 4 μg/d), D (26 μg/d, the reference is set to 20 μg/d), calcium (938 mg/d, the reference is set to 1000 mg/d) and iron (37 mg/d, the reference is set to 10–15 mg/d) were all adequate (except borderline low intake of calcium). However, the athlete's vitamin E and potassium intake were not adequate. In addition, sodium, chloride, and iodine intake were from food only (i.e., without meal preparation included); therefore, all were underreported.

Furthermore, in 2018, the athlete did not consume dietary supplements, while she now regularly uses several dietary supplements, including plant-based protein powder (i.e., hemp, peas, and coconut protein enriched with calcium, iron, potassium, and sodium), vitamin B_{12}, vitamin C, vitamin D daily during the autumn-winter period, iron, and tonic drink with iron together with vitamin C (again), and some B vitamins.

In line with dietary intake, the analysis showed that the athlete rarely consumed legumes and nuts/seeds (both groups 1–3 times per month); however, milk (daily), salmon fish (3 times per week), eggs, fruits, and oat flakes (all 5–6 times per week) were consumed as were meat (mostly chicken), other whole grain products (e.g., whole grain bread, whole grain pasta, rice), other dairy products (e.g., cheese or yogurt), and cooked vegetables 2–4 times per week. Raw

vegetables were rarely consumed. On most days, the athlete avoided unhealthy and ultra-processed foods (e.g., white flour products, sweets, mayonnaise) or unhealthy food preparation methods (e.g., frying). In addition, the athlete prepared most of her meals at home. Finally, the athlete regularly consumed all three meals: breakfast, lunch, and dinner (of note, the athlete reported that lunch was skipped once per week; we assume that on the day off training).

Table 1:
Ranking in important international competitions.

Parameter	Year 2018	Year 2022
Age (years)	24.9	28.9
High-profile ranking (place)		
World championship	-	
European championship (vault, 2017)	9th	
World cup overall (vault, 2016)	1rd	
World cup (vault, 2018)	1rd	
World cup (vault, 2015)	2nd	
World cup (vault, 2016)	2nd	
World championship (vault, 2021)		14th
European championship (vault, 2017)		4th
World cup (vault, 2021)		1rd
World cup (vault, 2022, 2022)		1rd
World cup (vault, 2021, 2021)		2nd

Table 2.
Anthropometrics and body composition changes.

Parameter	Year 2018	Year 2022	AG-2†	AG-3††
BH (cm)	151	151	157	154
BM (kg)	48.7	48.0	49.0	45.8
BMI (kg/m2)	21.4	21.1	19.9	19.3
BF (%)	20.8	19.9	16.3	11.7
Android (%)	14.2	**10.5**	13.2	-
Gynoid (%)	31.6	32.2	27.4	-
A/G	0.45	**0.33**	0.48	-
BFM (kg)	9.7	**8.7**	7.6	-
FFM (kg)	39.0	39.3	41.3	40.5
LST (kg)	36.7	37.0	38.8	-
BMC total (kg)	2.26	2.26	2.65	-
BMD total (g/cm^2)	1.24	1.25	1.32	-
BMD left femoral neck	1.35	1.31	1.27	-
BMD left femur	1.40	1.37	1.28	-
BMD legs	1.36	1.39	1.42	-
BMD pelvis	1.35	1.31	1.38	-
BMD spine	1.12	1.12	1.25	-
BMD trunk	0.99	0.98	1.06	-
BMD ribs	0.68	0.65	0.73	-
BMD arms	1.14	1.14	1.17	-
BMD head	2.08	2.12	2.22	-

Significant change in value is shown in bold (i.e., ≥ 9% of relative change). BH: body height, BM: body mass, BMI: body mass index, BF: body fat, FFM: fat-free mass, BFM: fat mass, A/G: android/gynoid ratio, LST: lean soft tissue, BMC: bone mineral content, BMD: bone mineral density (i.e., all variables in g/cm^2 units). †AG-2: elite-level artistic gymnast from our first study (i.e., best performer on the same apparatus (i.e., vault)) (Jakše, Jakše, Čuk, et al., 2021). ††AG-3: elite-level artistic gymnast from the study of other researchers (Dallas et al., 2016). Body composition of the AG-3 was estimated from skinfold thickness using a Lange skinfold caliper.

Table 3.
Intake of energy and macronutrients.

Macronutrients (per day)	Year 2018	Year 2022	AG-2†	AG-3††
Energy intake (kcal)	1476	1765	1759	1712
Carbohydrates (g)	150	**208**	165	-
(% E)	41	**47**	37	52
Carbohydrates (g/kg BM)	3.1	**4.3**	3.4	4.8
Total sugars[TS] (g)	69	**100**	123	-
(% E)	19	**23**	28	-
Free sugars[FS] (g)	48	**42**	75	-
(% E)	13	**9**	17	-
Starches (g)	57	69	45	-
(% E)	15	16	10	-
Dietary fiber (g)	17	**27**	11	15
(% E)	2.3	**3**	1.3	-
Soluble fiber (g)	4.1	**6.5**	4.1	-
Insoluble fiber	11	**14**	7	-
Fat (g)	70	**59**	93	-
(% E)	43	**30**	48	33
SFAs (g)	21	21	42	-
(% E)	13	**11**	21	-
MUFAs (g)	30	**20**	31	-
(% E)	18	**10**	16	-
PUFAs (g)	14	**9**	8	-
(% E)	8.5	**4.6**	4.1	-
EPA + DHA (mg)	100	**442**	98	-
Cholesterol (mg)	193	**376**	128	-
Protein (g)	53	**87**	60	-
(% E)	14	**20**	14	15
(g/BM)	1.1	**1.8**	1.2	1.4
Plant protein (g)	16	**35**	12	-
(% E)	4.3	**8**	2.7	-
Animal protein (g)	37	**52**	48	-
(% E)	10	**12**	11	-
Alcohol (g)	0.1	0	0	-
Total water[TW] (l)	1.6	**2.1**	1.3	2.9

Significant changes in value (i.e., 15% of relative change) are shown in bold. % E = percentage of total energy intake (general Atwater energy conversion factors were used (kcal/g): carbohydrates and protein = 4, dietary fiber = 2, fat = 9, alcohol = 7) (Food and Agriculture Organization of the United Nations, 2003). TS = total sugars: all monosaccharides and disaccharides: free sugars plus sugars naturally present in foods (e.g., lactose in milk, fructose in fruits) (WHO, 2015). FS = free sugar: all monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook, or consumer (i.e., added sugars) plus sugars naturally present in honey, syrups, fruit juices, fruit juice concentrates, and sports drinks (defined by the World Health Organization (WHO, 2015) and adapted by the Scientific Advisory Committee on Nutrition (Scientific Advisory Committee on Nutrition, 2015)). SFAs = saturated fatty acids; MUFAs = monounsaturated fatty acids; PUFAs = polyunsaturated fatty acids; EPA = eicosatetraenoic acid; DHA = docosahexaenoic acid. TW = total water: from beverages, solid foods, and supplementation. †AG-2: elite-level artistic gymnast from our first study (i.e., best performer on the same apparatus (i.e., vault)) (Jakše, Jakše, Fidler Mis, et al., 2021). ††AG-3: elite-level artistic gymnast from the study of other researchers (Dallas et al., 2016). Dietary intake of the AG-3 was assessed using three different methods: a) an arbitration history (emphasis on basic and customary intake) via personal interviews; b) a 7-day record of weighed food and drink consumption; and c) a FFQ with emphasis on foods rich in calcium and vitamin D.

Table 4.
Intake of selected vitamins, minerals, and trace elements.

Micronutrients (per day)	Year 2018	Year 2022	AG-2	AG-3
Vitamins				-
Thiamine (mg)	1.2	1.4	0.8	-
Riboflavin (mg)	1.6	2.7	2.0	-
Niacin (mg)	16	21	11	-
Pantothenic acid (mg)	6.4	9.0	4.1	-
Vitamin B6 (mg)	1.6	2.1	0.9	2.2
Biotin (µg)	78	97	76	-
Folate/folic acid^{FA} (µg)	283	468	340	-
Vitamin B_{12} (µg)	4.3	58	10.2	1.9
Retinol equ.^{RE} (mg)	1.4	2.1	2.5	-
Vitamin C (mg)	34	**302**	28	152
Vitamin D (µg)	5.4	**26**	3.8	-
Vitamin E (mg)	9.0	7.1	9.2	12.8
Vitamin K (µg)	75	**286**	55	-
Minerals				-
Calcium (mg)	410	**938**	696	878
Magnesium (mg)	261	**479**	291	287
Phosphorus (mg)	1219	**1656**	1091	994
Potassium (mg)	2235	**3342**	1510	-
Sodium (mg)†	966	**1358**	1696	-
Chloride (mg)†	1411	**1679**	1291	-
Trace elements				-
Iron (mg)	11	**37**	12	11.6
Iodine (µg)†	42	**56**	102	-
Zinc (mg)	8	**10**	10	9.4
Selenium (µg)	93	**171**	21	-

Significant changes in value (i.e., 15% of relative change) are shown in bold. FA = folic acid (of note, the athlete did not consume folic acid in dietary supplement form; therefore, the folic acid from supplementation to folate conversion was not used). RE = retinol equivalents: vitamin A + α-carotene (1 mg retinol equivalent = 12 mg α-carotene) + β-carotene (1 mg retinol equivalent = 6 mg β-carotene) + γ-carotene (1 mg retinol equivalent = 12 mg γ-carotene). †Sodium, chloride, and iodine intake are from food and supplements only (i.e., without iodized salt from meal preparation). The athlete did not consume many minimally processed, processed, or ultra-processed products or canned products that are included in the FFQ (e.g., mayonnaise, butter, lard, ketchup, confectionery, canned beans, cheese, fries, commercial bread, and pastries) and that include sodium; therefore, the recorded intake of sodium and chloride from food only may be lower than actual intake. †AG-2: elite-level artistic gymnast from our first study (i.e., best performer on the same apparatus (i.e., vault)) (Jakše, Jakše, Fidler Mis, et al., 2021). ††AG-3: elite-level artistic gymnast from the study of other researchers (Dallas et al., 2016). Dietary intake of the AG-3 was assessed using three different methods: a) an arbitration history (emphasis on basic and customary intake) via personal interviews, b) a 7-day record of weighed food and drink consumption, and c) a FFQ with emphasis on foods rich in calcium and vitamin D.

Table 5.
Serum micronutrient status.

Parameter	Reference†	Year 2018	Year 2022	AG-2†
Vitamins				
S-vit B_{12} (pmol/L)	≥ 258	284	**598**	224
25(OH)D (nmol/L)	≥ 75	55	**47**	89
Minerals				
S-Ca (mmol/L)	2.10–2.60	2.46	2.34	2.43
S-Mg mmol/L)	0.60–1.10	0.95	**0.79**	0.8
S-P (mmol/L)	0.84–1.45	1.75	1.29	1.09
S-K (mmol/L)	3.8–5.5	4.5	4.4	5.0
Trace element				
S-Fe (µmol/L)	10.7–28.6	10.4	**25.1**	17.9

Significant changes (i.e., 10% of relative change) in value are shown in bold. †Serum vitamin B_{12} (S-vit B_{12}) reference value is suggested to prevent neurocognitive disorders late in life (Wolters et al., 2004). For 25(OH)D status, we used three categories (i.e., sufficiency: > 75 nmol/L, insufficiency: 50–75 nmol/L, and deficiency: < 50 nmol/L) (Holick, 2009). Concentrations of serum minerals and trace elements used are from the national laboratory, the University Medical Centre Ljubljana, Slovenia (University Medical Centre Ljubljana, 2018). †AG-2: elite-level artistic gymnast from our first study (i.e., best performer on the same apparatus (i.e., vault)) (Jakše, Jakše, Fidler Mis, et al., 2021).

Table 6.
Cardiovascular (CV) health and safety factors.

Parameter	Recomm./Refer.†	2018	2022	AG-2†
S-cholesterol (mmol/L)	< 5.2	5.3	**4.7**	5.1
LDL cholesterol (mmol/L)	< 3.4	3.0	3.1	3.2
HDL cholesterol (mmol/L)	> 1.3	1.6	1.7	1.2
Triglycerides (mmol/L)	< 1.7	1.0	**0.6**	1.0
Blood pressure (mmHg)				
Systolic	120–129	111	115	99
Diastolic	80–84	78	79	66
S-glucose (mmol/L)	< 5.8	3.7	**4.4**	4.5
S-UA (µmol/L)	< 360	249	**293**	178
Hemoglobin (g/L)	≥ 120	149	**137**	137

Significant changes in value (i.e., 10%) are shown in bold. †Recommendations or reference values: S-cholesterol and HDL cholesterol reference values were from the national laboratory, the University Medical Centre Ljubljana, Slovenia (University Medical Centre Ljubljana, 2018). Low-density lipoprotein cholesterol (LDL cholesterol), triglycerides, and BP recommendations used were from the European Society of Cardiology (Visseren et al., 2021). S-glucose recommendations were used from the European Diabetes Epidemiology Group for lean adults (BMI < 25 kg/m²) (Borch-Johnsen, 1999). Serum uric acid (S-UA) consensual threshold is used for all healthy subjects (Desideri et al., 2014). For hemoglobin, we used recommended cut-offs for a non-anemic state from the World Health Organization for non-pregnant females (> 120 g/L) (WHO, 2011). †AG-2: elite-level artistic gymnast from our first study (i.e., best performer on the same apparatus (i.e., vault)) (Jakše, Jakše, Fidler Mis, et al., 2021).

Serum micronutrients are presented in Table 5. All vitamins and minerals were within reference ranges, except for 25(OH)D, in the deficiency category. Furthermore, S-P was increased in the 2018 study, while the value was now within the reference range. Moreover, a four-year comparison has shown that the athlete

markedly improved the S-Fe status that was below the reference range in the 2018 study.

The significant observation in comparing the measured results of a blood test is that all blood variables and BP (i.e., CV health and safety factors) obtained were within reference values. However, a four-year comparison has shown that the athlete lowered S-cholesterol, triglycerides, and hemoglobin while increasing LDL cholesterol, HDL cholesterol, S-glucose, and S-UA (Table 6).

DISCUSSION

To our knowledge, this kind of repeated (i.e., period of a four-year cycle) screening of the same elite-level adult female artistic gymnast with the same protocol and methods is rarely seen in the scientific literature. With our study, we highlighted five critical findings. First, our results confirmed the importance of monitoring and analyzing athletes with the same study protocol and methods. The benefits of regular monitoring of elite-level artistic gymnasts are primarily for the athlete and coach, followed by gymnasts competing at lower-level competitions (i.e., high-performance level and younger gymnasts) and the scientific and artistic gymnastic community. Second, a four-year comparison has shown that the gymnast markedly improved her body composition status (i.e., decreased BFM, android fat, and A/G ratio). Third, dietary intake analysis showed that nutrients that are generally of concern among (female) athletes (specifically, female gymnasts), such as fiber (borderline low intake), EPA and DHA, vitamin B_{12} and D, calcium (borderline low intake), iron, and zinc, were adequate. However, the athlete's vitamin E and potassium intake were not adequate. Furthermore, in 2018, the athlete did not consume dietary supplements, while she now regularly uses several dietary supplements, including enriched plant-based protein powder, isolated vitamin B_{12}, C, D, and iron. Fourth, in regard to the serum micronutrient status, all measured vitamins and minerals were within the reference ranges, except vitamin 25(OH)D, which was deficient, and S-Fe, which markedly improved, compared with the 2018 study. Finally, markers of CV health status were all within the reference values; however, LDL cholesterol status could improve.

A four-year comparison (2018 vs. 2022) in body composition indices measured in the same competitive phase and calendar period showed a noticeable improvement in terms of decreased BFM, android fat, and A/G ratio. Although our athlete was an adult gymnast, we emphasize that she maintained her BH in both studies (i.e., 151 cm) and had similar BM (48.7 kg and 48.0 kg) and BMI (21.4 kg/m^2 and 21.1 kg/m^2). The variables that were relatively unchanged were LST, BMC total, BMD total, and BMD segmental. These results are interesting in the sense that the athlete probably maintained, in addition to the overall dietary pattern, the pattern of training, and in terms of the selection of apparatus for which she prepared and competed and avoided major injuries. We assumed that the lower android fat (i.e., trunk and upper body) and consequently lower A/G ratio might also result from changed dietary intake (e.g., lower free sugar and total fat intake and higher protein intake) (Cava et al., 2017; Manore, 2015).

Compared with older data on 31 elite-level artistic gymnasts from the United States of America (i.e., US national team, measured by DEXA), our elite-level artistic gymnast was the same size (151 cm vs. 151 cm) but had higher BM (48.0 kg vs. 46.5 kg) and BF % (19.9 % vs. 12.4 %). However, our artistic gymnast was, at the time of the study, an experienced elite-level athlete, aged 28.9 years, compared to the mean age of only 15.2 years (Deutz et al., 2000) in the mentioned study. Furthermore, when comparing our results with another US study on 48 elite-level female gymnasts (there is no data on whether the sample included exclusively artistic gymnasts), in

which the researchers also used DEXA, these gymnasts were, on average, also significantly younger (15.8 years, the oldest was 19.2 years), but of similar size than our gymnast (152.2 cm), and BM (47.7 kg), with lower BF % (14.3%) and higher relative FFM (85% vs. 82% of BM). However, the US gymnasts had, on average, lower BMD total (1.06 g/cm^2 vs. 1.25 g/cm^2) (Bauer et al., 2005). The most relevant comparison of our gymnast may be with the most successful gymnast from the 2018 study (i.e., also a participant in the Olympic Games); her parade apparatus was also the vault. The compared gymnast was 6 cm taller (157 cm), with similar BM (49 kg), but consequently with a lower BMI (19.9 kg/m^2), lower BF % (16.3%), higher BMC total (2.65 kg vs. 1.25 kg), higher LST (38.8 kg vs. 37.0 kg), higher BMD total (1.32 g/cm^2 vs. 1.25 g/m^2), but not BMD left femoral neck (1.27 g/cm^2 vs. 1.31 g/cm^2) and left femur (1.28 g/cm^2 vs. 1.37 g/cm^2). The higher BMD total of the previously most successful gymnast was at the expense of higher BMD legs (1.42 g/cm^2), BMD pelvis (1.38 g/cm^2), BMD spine (1.25 g/cm^2), BMD trunk (1.06 g/cm^2), BMD ribs (0.73 g/cm^2), BMD arms (1.17 g/cm^2), and BMD head (2.22 g/cm^2) (Jakse et al., 2019; Jakše, Jakše, Čuk, et al., 2021). In addition, Greek researchers, although using a different method to assess the body composition status, measured lower BMI (19.3 kg/m^2) and BF % (11.7%) in an 18.5-year-old elite-level artistic gymnast (Dallas et al., 2016). Importantly, the available data in recent systematic reviews of elite-level female gymnasts used mostly outdated studies, and recent data are still not sufficient for providing robust conclusions about whether body composition features explain competitive performance (Bacciotti et al., 2017). We emphasize that there is a need for a more transparent use of the terms "elite-level" and "high-performance level" to avoid inappropriate comparisons. In addition, body composition is assessed with numerous methods (i.e., bioimpedance, DEXA, skinfold measurement), so direct comparisons are oftentimes limited.

The athlete, in terms of dietary intake, relied to a great extent on dietary supplements (i.e., four years ago, the athlete did not use them at all) with which she covered the nutritional sufficiency of certain nutrients (i.e., with enriched plant-based protein powder, vitamin B_{12}, C, D, and iron).

Furthermore, the estimated average carbohydrate intake of the athlete in the previous and current study (2018 vs. 2022) (3.1 g/kg BM/d vs. 4.3 g/kg BM/d) (Jakše, Jakše, Fidler Mis, et al., 2021) would be barely suitable for skilled-based intensity exercise (Thomas et al., 2016). Significantly, while the athlete in the current study markedly increased the energy intake (1476 kcal/d vs. 1765 kcal/d), carbohydrate (41% vs. 47 % of energy), and protein intake (14% vs. 20% of energy) and decreased total fat (43% vs. 30% of energy) and SFA intake (13% vs. 8% of energy), and unfavorable increased cholesterol intake (193 mg/d vs. 376 mg/d). However, although it may be different for other athletes with higher energy needs, the athlete's free sugar, SFA, and cholesterol intake were higher than recommended (DGE/ÖGE/SGE, 2018; Scientific Advisory Committee on Nutrition, 2015). Moreover, the athlete greatly increased fiber intake (17 g/d vs. 27 g/d), which represents borderline low intake compared with the reference intake (30 g/d) and EPA and DHA intake (100 mg/d vs. 442 mg/d) that were adequate (250 mg/d) (EFSA, 2017) at the time. However, the athlete had inadequate intake of vitamin E (7.1 mg/d, the reference is set to 12 mg/d) and potassium (3342 mg/d, the reference is set to 4000 mg/d) (National institute of Public Health of Slovenia, 2020). Micronutrients that are often of concern in the general population and among athletes (e.g., vitamin B_{12}, D, calcium (borderline low intake), and iron) were adequate. In addition, sodium, chloride, and iodine intake were from food only (i.e., without

meal preparation included); therefore, all were underreported; however, according to FFQ (i.e., dietary intake from foods and dietary supplements), we estimate that iodine intake is probably inadequate (National institute of Public Health of Slovenia, 2020).

In addition, in a rare recent investigation, its authors reported a case study of AG-3, members of the Greek National Team. Using an arbitration history of food intake via personal interview, 7-day weighed food record protocol and the FFQ, the researchers found that from assessed nutrients only vitamin C, vitamin B_6 and zinc exceeded daily recommended amounts, whereas fiber (14.7 g/d), vitamin B_{12} (1.2 µg/d) and calcium intake (878 mg/d) were insufficient and had the highest deviation from the recommended dietary intake (Dallas et al., 2016). Despite the fact that our results are hardly comparable to the values reported in this case study due to the use of a different method for assessing dietary intake, the database used, and the different nutrients that were included in the analysis, we can clearly see a similar trend of unbalanced nutrition in certain segments when compared with dietary intake recommendations.

In line with dietary intake, our analysis showed that the athlete severely limited her intake of raw vegetables, nuts/seeds, and legumes. However, the athlete consumed dairy products daily and whole grains, eggs, and fish on most days. The athlete regularly consumed all three main meals, prepared most of the meals at home and avoided unhealthy or ultra-processed food. Hence, the differences assessed in the dietary intake were consistent with the obtained differences in the S-vit B_{12} (improved), 25(OH)D (below the reference values), and S-Fe (improved), and CV health status (i.e., some variables increased, others (un)favorable decreased, and others remained at a similar level, and within recommendation). We emphasize three things in regard to obtained serum values of micronutrients. Firstly, the athlete's 25 (OH)D status was in the deficient category despite regular intake of vitamin D from a dietary supplement source. Significantly, the athlete consumed 1000 IU/d of vitamin D in the form of dietary supplements for the whole autumn and winter period. The current Slovenian recommendation, especially in periods of respiratory infections and covid-19 and due to the latitude of Slovenia (46 °N), advise taking daily up to 4000 IU, especially when tests show low concentrations of 25(OH)D (Pfeifer et al., 2020). In regard to (in)adequate vitamin D status, several studies have confirmed the existence of a problem of serum deficiencies in 25(OH)D among female athletes in general and artistic gymnasts specifically (Lovell, 2008; Quadri et al., 2016), which may increase the risk of stress fractures and illness, increase muscle weakness, and delay muscle recovery (Sikora-Klak et al., 2018). Secondly, the athlete regularly consumed animal-based food sources (e.g., salmon, fish, milk, and eggs) and vitamin B_{12} dietary supplements; therefore, based on her current S-vit B_{12} status (598 pmol/L), she may decrease the amount or the frequency of vitamin B_{12} intake from dietary supplement sources. Thirdly, high intake of iron from dietary supplements resulted in an improvement in S-Fe status in comparison with the 2018 study (10.4 µmol/L vs. 25.1 µmol/L).

In both studies, all CV health markers were within the reference values. Furthermore, the four-year comparison has shown that the athlete lowered S-cholesterol, triglycerides, and hemoglobin (as a safety marker) but increased the LDL cholesterol, HDL cholesterol, and S-UA as a safety marker. However, some noteworthy differences merit further examination, with several possible explanations for these observed differences. Furthermore, our athlete currently experiences increased LDL cholesterol (from 3.0 mmol/L in 2018 to 3.1 mmol/L in 2022) that might be explained by increased SFA, dietary cholesterol, and free sugar

intake, which are associated with an increased risk of CV diseases (Bergeron et al., 2019; Freeman et al., 2017; Sacks et al., 2017; Zhong et al., 2019), whereas dietary fiber (the athlete's fiber intake was borderline low) yields a reduction in LDL cholesterol (via reduced gastrointestinal absorption) (Veronese et al., 2018). The athlete regularly consumed oats and other whole grains that are known to have a favorable impact on LDL cholesterol (Cicero et al., 2020); however, in terms of the overall diet pattern, the athlete has reserves for more frequent intake of foods that are mostly absent from her diet and are also known to control LDL cholesterol (e.g., soy and other legumes, tomato, flaxseeds, walnuts, and green tea (Schoeneck & Iggman, 2021)). In addition, several studies suggest that LDL cholesterol levels greater than or equal to 2.6 mmol/L may be associated with preclinical atherosclerosis despite the absence of other risk factors. Moreover, this threshold may become a serious health concern or even fatal for athletes later in life (Abdullah et al., 2018; Fernández-Friera et al., 2017; O'Keefe et al., 2004). However, because the studied athlete was considered to have normal BM and BF %, as an athlete, she is regularly physically active, had regulated blood pressure (115/79 mmHg), normal levels of triglycerides (0.6 mmol/L), HDL cholesterol (1.7 mmol/L), non-HDL cholesterol (3.0 mmol/L) and she is non-smoker, according to SCORE2 risk prediction algorithms (Hageman et al., 2021) we believe that LDL cholesterol of 3.1 mmol/L is unlikely to pose a significant risk of cardiovascular disease. The athlete's higher HDL cholesterol was probably due to regular physical activity (Palazón-Bru et al., 2021) and coconut fat intake (Teng et al., 2020). However, while seminal observational studies have shown an inverse relationship between HDL-cholesterol and atherosclerotic risk, recent evidence suggests that high and extremely high HDL-cholesterol may not reduce the risk of CV disease events or may even be associated with increased all-cause mortality. The lowest risk was seen for HDL cholesterol to be between 1.4 mmol/L to 1.5 mmol/L (Zhong et al., 2020). Regulated blood pressure in both studies, although with insufficient potassium intake, is most likely due to lower salt intake (food preparation at home) and daily whole grains and fruit intake (Stamler et al., 2018).

The present case study report examined an elite-level adult female national team artistic gymnast, currently the most successful one representing Slovenia. Although the athlete was already considered an elite-level in the first study four years ago, she was not the best performer in the country at that time (i.e., 2018) or as successful as at present. Significantly, in the study we used the same competitive and calendar period, the same location (i.e., medical center), the same protocol, and the same wide data sets of objective methods, and compared the athlete's change/progress over the four-year range. Therefore, the novelty of our results with two screenings of the successful elite-level artistic gymnast under the same conditions enables valuable interpretations of the results obtained. In addition, this kind of screening or monitoring showed its usefulness as it is affordable, carried out using valid methods, and is not time-consuming. The study has some obvious limitations inherent to the case study design; therefore, the results should be interpreted with caution regarding application of the results to other national team members. Furthermore, when analyzing the dietary assessment we are aware of the possibility that the energy and nutrients intake were underreported or underestimated (Capling et al., 2017). This issue is especially relevant for female artistic gymnasts because of known problems with under-reporting of energy intake by elite-level female gymnasts (Jonnalagadda et al., 2000). The nature of FFQ itself (i.e., completing FFQ from memory and perception), especially for one athlete only, differs significantly from, for

example, a three-day (weighted) dietary record. Notably, the athlete did not have access to the completed FFQ from 2018. Moreover, the obtained FFQ results were further considered in the context of body composition and extensive blood tests results. At the time of the study, our elite-level athlete was not using any periodized nutrition plan, as recommended by most professionals (Jeukendrup, 2017). In addition, there is a lack of follow-up scientific studies on elite-level female gymnasts that would monitor their various changes; therefore, there is a need for further studies to investigate the curve of changes in the monitored variables (also the motor skills) of the athlete that affect the sports performance and the development of her sports career.

CONCLUSION

A four-year comparison of the results of the elite-level female athlete has shown an improvement in some relevant body composition variables. Furthermore, the dietary intake of the athlete also showed several improvements regarding the adequacy of nutrients that are generally of concern among female athletes; however, most improvement was primarily achieved through several supplementations on a daily basis. In fact, the athlete did not regularly consume supplementation four years ago. Furthermore, all the measured serum micronutrients were within the reference ranges, and S-Fe was markedly improved. Finally, the CV health status was within the reference values, but the changes were polarized; S-cholesterol was favorable, while triglycerides unfavorably decreased. In the long run, LDL cholesterol should probably be lower.

The obtained results may provide helpful concrete information for a coach-athlete relationship, for an artistic gymnast at lower-level competitions, and for the development of elite-level artistic gymnasts in Slovenia.

AKNOWLEDGMENTS

Research was supported by the authors' initiative. The gymnast signed an informed consent form for inclusion in the study. The data used to support the findings of this study are included within the article.

The authors wish to thank the gymnast for their collaboration and participation in our study.

The authors declare no conflict of interests related to this manuscript.

REFERENCES

Ackland, T. R., Lohman, T. G., Sundgot-Borgen, J., Maughan, R. J., Meyer, N. L., Stewart, A. D., & Mller, W. (2012). Current status of body composition assessment in sport: review and position statement on behalf of the ad hoc research working group on body composition health and performance, under the auspices of the I.O.C. Medical Commission. *Sports Medicine*, *42*(3), 227–249.

Anderson, C., & Petrie, T. A. (2012). Prevalence of Disordered Eating and Pathogenic Weight Control Behaviors Among NCAA Division I Female Collegiate Gymnasts and Swimmers. *Research Quarterly for Exercise and Sport*, *83*(1), 120–124.

Bacciotti, S., Baxter-Jones, A., Gaya, A., & Maia, J. (2017). The Physique of Elite Female Artistic Gymnasts: A Systematic Review. *Journal of Human Kinetics*, *58*(1), 247–259.

Bauer, P. W., Pivarnik, J. M., Fornetti, W. C., Jallo, J. J., & Nassar, L. (2005). Cross Validation of Fat-Free Mass Prediction Models for Elite Female Gymnasts. *Pediatric Exercise Science*, *17*(4), 337–344.

Bergeron, N., Chiu, S., Williams, P. T., M King, S., & Krauss, R. M. (2019). Effects of red meat, white meat, and nonmeat protein sources on atherogenic lipoprotein measures in the context of low compared with high saturated fat intake: a randomized controlled trial. *The American Journal of*

Clinical Nutrition, *110*(1), 24–33.

Borch-Johnsen, K. (1999). Is fasting glucose sufficient to define diabetes? Epidemiological data from 20 European studies. *Diabetologia*, *42*(6), 647–654.

Capling, L., Beck, K. L., Gifford, J. A., Slater, G., Flood, V. M., & O'Connor, H. (2017). Validity of Dietary Assessment in Athletes: A Systematic Review. *Nutrients*, *9*(12), 1313.

Cava, E., Yeat, N. C., & Mittendorfer, B. (2017). Preserving Healthy Muscle during Weight Loss. *Advances in Nutrition: An International Review Journal*, *8*(3), 511–519.

Cicero, A. F. G., Fogacci, F., Veronesi, M., Strocchi, E., Grandi, E., Rizzoli, E., Poli, A., Marangoni, F., & Borghi, C. (2020). A randomized Placebo-Controlled Clinical Trial to Evaluate the Medium-Term Effects of Oat Fibers on Human Health: The Beta-Glucan Effects on Lipid Profile, Glycemia and inTestinal Health (BELT) Study. *Nutrients*, *12*(3), 686.

Clarys, P., Deliens, T., Huybrechts, I., Deriemaeker, P., Vanaelst, B., De Keyzer, W., Hebbelinck, M., & Mullie, P. (2014). Comparison of nutritional quality of the vegan, vegetarian, semi-vegetarian, pesco-vegetarian and omnivorous diet. *Nutrients*, *6*(3), 1318–1332.

Dallas, G. C., Dallas, C. G., Simatos, E. J., & Simatos, J. E. (2017). Nutritional recommendations and guidelines for women in gymnastics: current aspects and critical interventions. *Science of Gymnastics Journal*, *9*(1), 27–40.

Dallas, G., Dallas, C., & Simatos, J. (2016). Nutritional status and dietary assessment of elite female artistic and rhythmic gymnasts - a case study. *Science of Gymnastics Journal*, *8*(3), 255–269. http://eds.b.ebscohost.com.nukweb.nuk.uni-lj.si/eds/detail/detail?vid=0&sid=059ffe90-025d-4fe6-a8e8-20a835c709ef%40pdc-v-sessmgr06&bdata=Jmxhbmc9c2wmc2l0ZT1lZHMtbGl2ZQ%3D%3D#AN=119297738&db=s3h

De Keyzer, W., Dekkers, A., Van Vlaslaer, V., Ottevaere, C., Van Oyen, H., De Henauw, S., & Huybrechts, I. (2013). Relative validity of a short qualitative food frequency questionnaire for use in food consumption surveys. *The European Journal of Public Health*, *23*(5), 737–742.

Desideri, G., Castaldo, G., Lombardi, A., Mussap, M., Testa, A., Pontremoli, R., Punzi, L., & Borghi, C. (2014). Is it time to revise the normal range of serum uric acid levels? *European Review for Medical and Pharmacological Sciences*, *18*(9), 1295–1306. http://www.ncbi.nlm.nih.gov/pubmed/24867507

Deutz, R. C., Benardot, D., Martin, D. E., & Cody, M. M. (2000). Relationship between energy deficits and body composition in elite female gymnasts and runners. *Medicine and Science in Sports and Exercise*, *32*(3), 659–668.

DGE/ÖGE/SGE. (2018). *Ergaenzlieferung D-A-CH Referenzwerte für die Nährstoffzufuhr [Reference Values for Nutrient Intake]* (4th ed, pp. 1–56).

EFSA. (2017). Dietary Reference Values for nutrients Summary report. *EFSA Supporting Publications*, *14*(12), e15121.

FIG. (2022). *Kysselef Tjaša - FIG Athlete Profile*. Federation Internationale De Gymnastique. https://www.gymnastics.sport/site/athletes/bio_detail.php?id=25211

Food and Agriculture Organization of the United Nations. (2003). *Food energy – methods of analysis and conversion factors*. https://www.sennutricion.org/media/Docs_Consenso/Food_energy_methods_of_analysis_and_conversion_factors-FAO_2002.pdf

Freeman, A. M., Morris, P. B., Barnard, N., Esselstyn, C. B., Ros, E., Agatston, A., Devries, S., O'Keefe, J., Miller, M., Ornish, D., Williams, K., & Kris-Etherton, P. (2017). Trending Cardiovascular Nutrition Controversies. *Journal of the American College of Cardiology*, *69*(9), 1172–1187.

Hageman, S., Pennells, L., Ojeda, F., Kaptoge, S., Kuulasmaa, K., de Vries, T.,

Xu, Z., Kee, F., Chung, R., Wood, A., McEvoy, J. W., Veronesi, G., Bolton, T., Achenbach, S., Aleksandrova, K., Amiano, P., Sebastian, D.-S., Amouyel, P., Andersson, J., … Di Angelantonio, E. (2021). SCORE2 risk prediction algorithms: new models to estimate 10-year risk of cardiovascular disease in Europe. *European Heart Journal*, *42*(25), 2439–2454.

Heaney, R. P. (2005). The Vitamin D requirement in health and disease. *The Journal of Steroid Biochemistry and Molecular Biology*, *97*(1–2), 13–19.

Holick, M. F. (2009). Vitamin D Status: Measurement, Interpretation, and Clinical Application. *Annals of Epidemiology*, *19*(2), 73–78.

Institute of Medicine. (1998). Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic Acid, Biotin, and Choline. In *Dietary Reference Intakes for Thiamin, Riboflavin, Niacin, Vitamin B6, Folate, Vitamin B12, Pantothenic Acid, Biotin, and Choline*. National Academies Press (United States).

Jakše, B., Jakše, B., Čuk, I., & Šajber, D. (2021). Body Composition, Training Volume/Pattern and Injury Status of Slovenian Adolescent Female High-Performance Gymnasts. *International Journal of Environmental Research and Public Health*, *18*(4), 2019.

Jakše, B., Jakše, B., Fidler Mis, N., Jug, B., Šajber, D., Godnov, U., & Čuk, I. (2021). Nutritional Status and Cardiovascular Health in Female Adolescent Elite-Level Artistic Gymnasts and Swimmers: A Cross-Sectional Study of 31 Athletes. *Journal of Nutrition and Metabolism*, *2021*, 8810548. https://doi.org/10.1155/2021/8810548

Jakše, B., Jakše, B., Godnov, U., & Pinter, S. (2021). Nutritional, Cardiovascular Health and Lifestyle Status of 'Health Conscious' Adult Vegans and Non-Vegans from Slovenia: A Cross-Sectional Self-Reported Survey. *International Journal of Environmental Research and Public Health*, *18*(11), 5968.

Jakse, B., Sekulic, D., Jakse, B., Cuk, I., & Sajber, D. (2019). Bone health among indoor female athletes and associated factors; a cross-sectional study. *Research in Sports Medicine*, *28*(3), 314–323.

Jeukendrup, A. E. (2017). Periodized Nutrition for Athletes. *Sports Medicine*, *47*(Suppl 1), 51–63.

Jonnalagadda, S. S., Benardot, D., & Dill, M. N. (2000). Assessment of Under-Reporting of Energy Intake by Elite Female Gymnasts. *International Journal of Sport Nutrition and Exercise Metabolism*, *10*(3), 315–325.

Jungert, A., Ellinger, S., Watzl, B., & Richter, M. (2022). Revised D-A-CH reference values for the intake of biotin. *European Journal of Nutrition*, *61*(4), 1779–1787.

Jungert, A., Linseisen, J., Wagner, K. H., & Richter, M. (2020). Revised D-A-CH Reference Values for the Intake of Vitamin B6. *Annals of Nutrition and Metabolism*, *76*(4), 213–222.

Korošec, M., Golob, T., Bertoncelj, J., Stibilj, V., & Seljak, B. K. (2013). The Slovenian food composition database. *Food Chemistry*, *140*(3), 495–499.

Lee, E. C., Fragala, M. S., Kavouras, S. A., Queen, R. M., Pryor, J. L., & Casa, D. J. (2017). Biomarkers in Sports and Exercise: Tracking Health, Performance, and Recovery in Athletes. *Journal of Strength and Conditioning Research*, *31*(10), 2920.

Ljungqvist, A., Jenoure, P., Engebretsen, L., Alonso, J. M., Bahr, R., Clough, A., De Bondt, G., Dvorak, J., Maloley, R., Matheson, G., Meeuwisse, W., Meijboom, E., Mountjoy, M., Pelliccia, A., Schwellnus, M., Sprumont, D., Schamasch, P., Gauthier, J. B., Dubi, C., … Thill, C. (2009). The International Olympic Committee (IOC) Consensus Statement on periodic health evaluation of elite athletes March 2009. *British Journal of Sports Medicine*, *43*(9), 631–643.

Lovell, G. (2008). Vitamin D status of females in an elite gymnastics program. *Clinical Journal of Sport Medicine*, *18*(2),

159–161.

Malsagova, K. A., Kopylov, A. T., Sinitsyna, A., Stepanov, A. A., Izotov, A. A., Butkova, T. V., Chingin, K., Klyuchnikov, M. S., & Kaysheva, A. L. (2021). Sports Nutrition: Diets, Selection Factors, Recommendations. *Nutrients*, *13*(11), 3771.

Manore, M. M. (2015). Weight Management for Athletes and Active Individuals: A Brief Review. *Sports Medicine (Auckland, N.Z.)*, *45*(Suppl 1), 83.

Monteiro, C. A., Cannon, G., Levy, R. B., Moubarac, J. C., Louzada, M. L. C., Rauber, F., Khandpur, N., Cediel, G., Neri, D., Martinez-Steele, E., Baraldi, L. G., & Jaime, P. C. (2019). Ultra-processed foods: what they are and how to identify them. *Public Health Nutrition*, *22*(5), 936–941.

National institute of Public Health of Slovenia. (2020). *Reference values for energy intake and nutrient intake*. https://www.nijz.si/sites/www.nijz.si/files/uploaded/referencne_vrednosti_2020_3_2.pdf

OPKP. (2021). *Computer web-based software: the Open Platform for Clinical Nutrition (OPEN)*. OPKP. Odprta Platforma Za Klinično Prehrano. http://www.opkp.si/sl_SI/fooddiary/diary

Palazón-Bru, A., Hernández-Lozano, D., & Gil-Guillén, V. F. (2021). Which Physical Exercise Interventions Increase HDL-Cholesterol Levels? A Systematic Review of Meta-analyses of Randomized Controlled Trials. *Sports Medicine (Auckland, N.Z.)*, *51*(2), 243–253.

Pfeifer, M., Siuka, D., & Pravst, I. (2020). *Priporočila za nadomeščanje holekalciferola (vitamina D3) v obdobjih respiratornih okužb in za nadomeščanje holekalciferola pri posameznikih s COVID-19*.

Quadri, A., Gorjanovic, B., Noack, P., Fuhrer, C., Steuer, C., Huber, A., & Kriemler, S. (2016). Seasonal variation of vitamin D levels in Swiss athletes. *Swiss Sports & Exercise Medicine*, *64*(1), 19–25.

Sacks, F. M., Lichtenstein, A. H., Wu, J. H. Y., Appel, L. J., Creager, M. A., Kris-Etherton, P. M., Miller, M., Rimm, E. B., Rudel, L. L., Robinson, J. G., Stone, N. J., Van Horn, L. V., & American Heart Association. (2017). Dietary Fats and Cardiovascular Disease: A Presidential Advisory From the American Heart Association. *Circulation*, *136*(3), e1–e23.

Schoeneck, M., & Iggman, D. (2021). The effects of foods on LDL cholesterol levels: A systematic review of the accumulated evidence from systematic reviews and meta-analyses of randomized controlled trials. *Nutrition, Metabolism, and Cardiovascular Diseases : NMCD*, *31*(5), 1325–1338.

Scientific Advisory Committee on Nutrition. (2015). *Carbohydrates and Health*. The Stationery Office. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/445503/SACN_Carbohydrates_and_Health.pdf

Sikora-Klak, J., Narvy, S. J., Yang, J., Makhni, E., Kharrazi, F. D., & Mehran, N. (2018). The Effect of Abnormal Vitamin D Levels in Athletes. *The Permanente Journal*, *22*.

Stamler, J., Chan, Q., Daviglus, M. L., Dyer, A. R., Van Horn, L., Garside, D. B., Miura, K., Wu, Y., Ueshima, H., Zhao, L., & Elliott, P. (2018). Relation of dietary sodium (Salt) to blood pressure and its possible modulation by other dietary factors the intermap study. *Hypertension*, *71*(4), 631–637.

Teng, M., Zhao, Y. J., Khoo, A. L., Yeo, T. C., Yong, Q. W., & Lim, B. P. (2020). Impact of coconut oil consumption on cardiovascular health: a systematic review and meta-analysis. *Nutrition Reviews*, *78*(3), 249–259.

Thomas, D. T., Erdman, K. A., & Burke, L. M. (2016). Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance. *Journal of the Academy of Nutrition and Dietetics*, *116*(3), 501–528.

Tobias, D. K., & Hall, K. D. (2021).

Eliminate or reformulate ultra-processed foods? Biological mechanisms matter. *Cell Metabolism*, *33*(12), 2314–2315.

University Medical Centre Ljubljana. (2018). *Laboratorijski vodnik*. https://lab.biarti.si/

Veronese, N., Solmi, M., Caruso, M. G., Giannelli, G., Osella, A. R., Evangelou, E., Maggi, S., Fontana, L., Stubbs, B., & Tzoulaki, I. (2018). Dietary fiber and health outcomes: an umbrella review of systematic reviews and meta-analyses. *The American Journal of Clinical Nutrition*, *107*(3), 436–444.

Visscher, C., Louer, L. E. A. M., & Elferink-Gemser, M. T. (2012). The perfect elite gymnast, does he exist? A systematic review. *Annals of Research in Sport and Physical Activity*, *3*, 39–61.

Visseren, F. L. J., MacH, F., Smulders, Y. M., Carballo, D., Koskinas, K. C., Bäck, M., Benetos, A., Biffi, A., Boavida, J. M., Capodanno, D., Cosyns, B., Crawford, C., Davos, C. H., Desormais, I., DI Angelantonio, E., Franco, O. H., Halvorsen, S., Hobbs, F. D. R., Hollander, M., … Williams, B. (2021). 2021 ESC Guidelines on cardiovascular disease prevention in clinical practice. *European Heart Journal*, *42*(34), 3227–3337.

WHO. (2011). Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. In *Vitamin and Mineral Nutrition Information System*. World Health Organization. https://apps.who.int/iris/bitstream/handle/10665/85839/WHO_NMH_NHD_MNM_11.1_eng.pdf?sequence=22&isAllowed=y

WHO. (2015). *Guideline: Sugars intake for adults and children*. World Health Organization: page 16. https://www.who.int/publications/i/item/9789241549028

Wolters, M., Ströhle, A., & Hahn, A. (2004). Cobalamin: A critical vitamin in the elderly. *Preventive Medicine*, *39*(6), 1256–1266.

Zhong, G. C., Huang, S. Q., Peng, Y., Wan, L., Wu, Y. Q. Le, Hu, T. Y., Hu, J. J., & Hao, F. B. (2020). HDL-C is associated with mortality from all causes, cardiovascular disease and cancer in a J-shaped dose-response fashion: a pooled analysis of 37 prospective cohort studies. *European Journal of Preventive Cardiology*, *27*(11), 1187–1203.

Zhong, V. W., Van Horn, L., Cornelis, M. C., Wilkins, J. T., Ning, H., Carnethon, M. R., Greenland, P., Mentz, R. J., Tucker, K. L., Zhao, L., Norwood, A. F., Lloyd-Jones, D. M., & Allen, N. B. (2019). Associations of Dietary Cholesterol or Egg Consumption With Incident Cardiovascular Disease and Mortality. *JAMA*, *321*(11), 1081–1095.

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Article received: 10.6.2022
Article accepted: 26.1.2023

THE STATE OF THE ART IN ACROBATIC GYMNASTICS: A BIBLIOMETRIC ANALYSIS

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Original article *DOI:15.1.47-63*

Abstract
Since acrobatic gymnastics is a recent gymnastics discipline, with only a few decades old, it is not yet much explored as a scientific research field. Despite its increasing popularity, and while science mapping has become an essential activity for all scientific disciplines, no bibliometric analysis on this topic was available. Therefore, this study aims to provide a static picture of the scientific research development in acrobatic gymnastics by collecting information about the main contributors as well as the main investigation topics, the publication dynamics and cooperative networks. A search conducted in the Web of Science and Scopus databases retrieved 37 journal articles between 2001-2021. Results suggest that the year of 2015 was a milestone for scientific research in acrobatic gymnastics since it marked the beginning of the dominance of authors from Spain, followed by Poland and Portugal. Countries are generally focused on their own territory and there is a limited scientific collaboration between different nations. The Spanish and the Polish research institutions are leading publishing in this sport. As a reference for future studies, our results suggest that although balance was identified as the niche investigation topic, there has been a lack of interest for the pyramids balance, which is a major feature of acrobatic gymnastics.

Keywords: *acrobatic gymnastics; bibliometric analysis; scientific production.*

INTRODUCTION

According to the Fédération Internationale de Gymnastique (2020), acrobatic gymnastics, initially called sports acrobatics, emerged as a competitive discipline from the Soviet Union, with the first national championship in 1939. Since the Second World War interrupted the development of this gymnastics discipline, the first international competition was held later, in Warsaw, in 1957, with the participation of four Eastern-bloc teams.

On November 23, 1973, the International Federation of Sports Acrobatics (IFSA) was established as the world governing body representing acrobatic gymnastics. However, in 1998, the IFSA was dissolved and the discipline was incorporated in the International Gymnastics Federation (FIG), with the overreaching goal to unite all gymnastics disciplines and to support acrobatics ultimately become an Olympic sport. The Acrobatic Gymnastics 16th World

Championship and the first world championship in the FIG era took place in Ghent, Belgium, in 1999 (Fédération Internationale de Gymnastique, 2020).

Since 2007, this discipline has been known as acrobatic gymnastics. It is characterized by the execution of static elements, such as balances and holds, and dynamic elements, such as lifts and throws with complex somersaults and twists, executed in pairs/groups, set to music and interspersed with choreography (Fédération Internationale de Gymnastique, 2020). Since acrobatic gymnastics is only a few decades old gymnastics discipline, it is not yet much explored as a scientific research field (Floria, Gomez-Landero, & Harrison, 2015; Leal Del Ojo, Floría, Harrison, & Gómez-Landero, 2020).

For a particular research domain, scholars tend to focus on the literature generated by the relevant scientific community (Aria, Misuraca, & Spano, 2020). Therefore, science mapping becomes an essential activity for scholars in all scientific disciplines (Aria & Cuccurullo, 2017) and bibliometric methods provide a quantitative perspective on the relevant literature for a given domain (Aria & Cuccurullo, 2017). They structure fields differently to the traditional literature reviews classification by providing a static field's picture at a particular moment (Aria et al., 2020). In acrobatic gymnastics, this analysis can be particularly important to identify the current research focus and which areas may be underexplored, allowing research efforts to be directed towards topics relevant to the sport development.

To the best of our knowledge, no bibliometric analysis on acrobatic gymnastics has been conducted to date despite its increase in popularity among different age groups (Taboada-Iglesias, Gutierrez-Sanchez, & Vernetta Santana, 2016; Taboada-Iglesias, Vernetta Santana, & Gutiérrez-Sánchez, 2017), underscoring a clear absence of information. Therefore, this study aims to provide a clear understanding of the current situation in acrobatic gymnastics by collecting information about the main contributors (countries, affiliations and authors), as well as the main investigation topics, the publication dynamics, and the cooperative networks between countries. This work may serve as a reference for future acrobatic gymnastics studies by identifying the areas that should be explored further.

METHODS

A database search was conducted on December 31, 2021, in the Clarivate Analytics Web of Science (WoS) and Scopus dabatases. The compatibility with the software used and the fact that WoS integrated the information from other databases while Scopus allowed the inclusion of a more comprehensive time window were the main reasons for the selection of these two databases. A topic search (article title, abstract, author keywords and keywords plus) was performed in WoS including the following search key: "gymnastic* AND (acrobatic* NOT artistic* NOT rhythmic* NOT aerobic*)". Since in the SCOPUS dabatase the operator NOT is equivalent to AND NOT and the topic search is not available, a search within the article title, abstract and author keywords was conducted, and the search key was adapted to the following: "gymnastic* AND (acrobatic* AND NOT artistic* AND NOT rhythmic* AND NOT aerobic*)". Only journal articles were selected for this study, but no time or language filters were applied.

The full record and cited references were retrieved. The resulting data were analyzed using the Bibliometrix toolbox (Aria & Cuccurullo, 2017) and its graphic user interface Biblioshiny, in RStudio 1.4.1106 (RStudio Inc., Boston, Massachusetts, USA) for a descriptive and quantitative data analysis. This process included the extraction of data set information, documents, and authors and sources information, as well as their

dynamics. For the information ranking, the top 5 elements were reported, except for the Core Sources assessment which are ranked according to the Bradford's Law (Bradford SCE, Egan M, & Shera JH, 1953).

RESULTS AND DISCUSSION

Document elegibility process is depicted in Figure 1. A total of 159 documents were retrieved (WoS, n = 79, and Scopus, n = 80), with dates ranging between 1999-2021 (WoS) and 1960-2021 (Scopus). The two databases information was merged into one single file, resulting in the authomatic detection and removal of 35 duplicated entries, leaving 124 documents. Although keywords were selected to avoid the inclusion of other gymnastics disciplines content, the results included articles from artistic gymnastics and "acrobatic elements" refering to floor routines. Therefore, the database was reviewed and only documents that included either a) acrobatic gymnasts, or b) acrobatic gymnastics content were retained for further analysis. This led us to exclude 82 and retain 42 documents. Five other documents were excluded since they were not journal articles but articles from congresses (n = 3), letters (n = 1) and editorials (n = 1).

After the database review and clean-up, 37 documents related to acrobatic gymnastics were used for this bibliometric study. These documents were written in English (n = 26), Spanish (n = 9), Portuguese (n = 1), or Russian (n = 1).

The following results and the discussion section are divided in six subsections: 1) publication dynamics according to countries' contributions and citations received; 2) the most productive and locally cited authors; 3) the most productive affiliations and collaboration networks; 4) the most locally and globally cited documents; 5) journal dynamics according to the core sources and the most cited journals, and 6) the conceptual structure, aiming to define 4 themes that may serve as a reference for future studies in this research field.

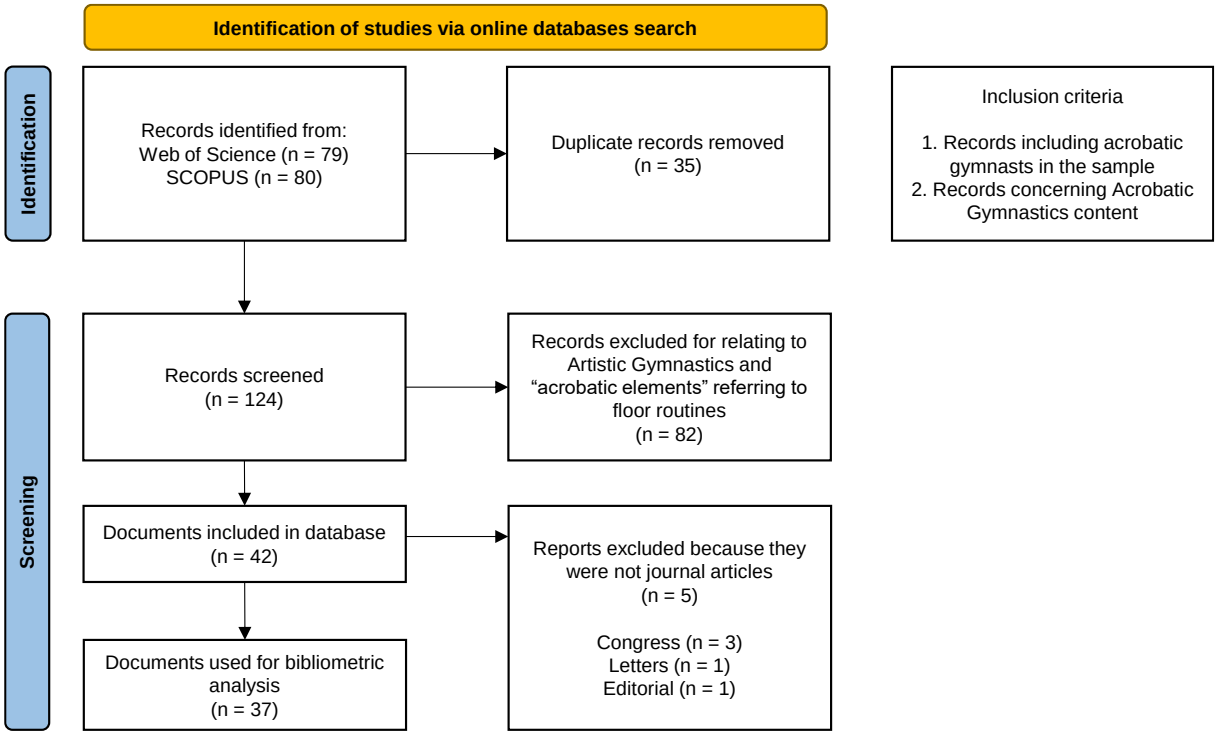

Figure 1. Document identification, screening and eligibility process.

The 37 retrieved documents were published between 2001-2021. On average, there were 2.65 citations per document and 0.76 citations per year and per document. These results suggest that acrobatic gymnastics is a recent gymnastics discipline with a limited scientific production, Documents on acrobatic gymnastics also have limited citations. The fact that each document presents an increase of only 0.76 citations per year suggests a slow progress of science in this field. A bibliometric analysis conducted in men's artistic gymnastics retrieved 52 documents distributed between 1994 and 2019 (Vargas & Capraro, 2020). In fact, between 1994 and 2014, the highest number of annual publications was 3 documents (2007, 2011 and 2021). These authors found the period between 2015 and 2018 as the most productive, totalling 5 (2015 and 2016), 8 (2017) and 9 documents published (2018). It seems that although men's artistic gymnastics was the first gymnastics discipline in the Olympic program, its scientific research field is still much less active than, e.g., women's artistic gymnastics. Although some systematic reviews about women's artistic gymnastics have been conducted (Campbell, Bradshaw, Ball, Pease, & Spratford, 2019; Prassas, Kwon, & Sands, 2006; Sterkowicz-Przybycien & Gualdi-Russo, 2018), a bibliometric review was not found for comparison. In acrobatic gymnastics, even though the overall annual growth rate of scientific production is 26%, there have been wide fluctuations over time (Figure 2). The first three journal articles in acrobatic gymnastics were published in 2001, 2008 and 2010. Although other types of publication (conference papers, letter, editorials and books) might might have been published in these years, there was no journal article. 2015 was a milestone for scientific research in acrobatic gymnastics since it marked the beginning of a continuous publication on this topic, most likely due to its increasing popularity (Taboada-Iglesias et al., 2016; Taboada-Iglesias et al., 2017). In men's artistic gymnastics (Vargas & Capraro, 2020), the scientific production also varies over time, with 2018 being the most productive year to date. These authors found an increase in publications from 2015 onwards, similarly to our results. The increase in scientific production was associated with the expansion of search platforms, especially in the last decade (Ciomaga, 2013; Lindahl, Stenling, Lindwall, & Colliander, 2015; Peset Mancebo et al., 2013; Prieto, Gómez, & Sampaio, 2015). Both men's artistic and acrobatic gymnastics disciplines share a lack of a continuous growth in publications. Nevertheless, 2015 marks the beginning of a dominance of publications in acrobatic gymnastics by authors affiliated to Spanish institutions, authoring 4 of the 6 journal articles in 2015, and 60.6% of the articles henceforth.

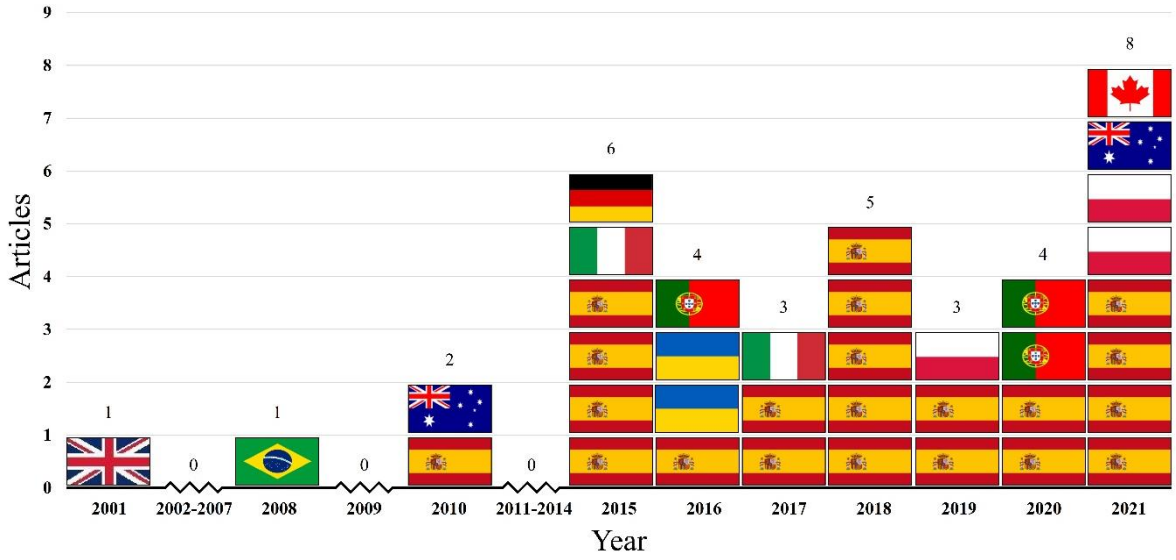

Figure 2. Number of acrobatic-gymnastics-related articles published annually by each country (2001-2021).

The prevalence of Spanish publications has a direct effect on the annual productivity. Years with fewer Spanish publications led to a decrease in the publication growth, suggesting that research in acrobatic gymnastics is mostly driven by these researchers, and that they have the greatest influence. However, the decrease in 2020 deserves further attention. In addition to an overall reduction of publications, and those affiliated with Spanish institutions in particular, the COVID-19 pandemic has negatively affected the usual research process (Radecki & Schonfeld, 2021) as can be seen in another bibliometric review (Fonseca, Goethel, Vilas-Boas, Gutierres, & Correia, 2021). Major competitions, such as the Acrobatic Gymnastics World Championship 2020 to be held in Geneva, Switzerland, were postponed to 2021, leading to a record participation of 40 nations and 1000 athletes (Fédération Internationale de Gymnastique, 2020), and providing a strong potential reason why 2021 was the most productive year. Whether this was a sporadic occurrence due to outstanding circumstances and not part of the normal publication growth can only be established in years to come. The fact is that 9 articles were published in 2021, with Spain showing again their predominance, followed by contributions from other nations, such as Poland, Australia, and the first publication from Canada. Table 1 depicts the total acrobatic gymnastics scientific production and citations count for each country.

Poland and Portugal are tied in second place in terms of productivity, each with 3 articles published. Despite its traditional position in gymnastics, particularly acrobatics, Ukraine only presented two publications. Brazil obtained great results in the latest Olympic games in women's artistic gymnastics but has no tradition in acrobatics, which can also be seen from the FIG results. Accordingly, Brazil only published one article in 2008 in acrobatic gymnastics. According to the Table 1, most publications are authored by researchers of a single country (SCP), while Spain and Canada are engaged in collaborations of multiple countries (MCP). The ratio between SCP and MCP publications suggests that countries are generally focused on their own territory, and that there is a limited scientific collaboration between nations in this domain.

In terms of citations per country, a higher number of publications is normally associated with an increased number of citations (Sandström & van den Besselaar, 2016). While this is the case for Spain, Poland and Portugal, Australian publications have received considerable attention. Out of the 31 citations Australia has received, Purnell, Shirley, Nicholson, and Adams (2010) alone had 28, which is almost the same number of citations as for all Spanish publications together. The authors addressed an issue in acrobatic gymnastics that can also be applied to other sports. Some of the citing articles are related to football, pole dancing, dancing, overall sports, injury, or pain. This is also beneficial to acrobatic gymnastics science, as it places the discipline in a position where it can serve as a reference to others. Despite numerous reasons to cite an article (Garfield, 1970), such numbers suggest important advances in the topic. Australia might have increased the number of citations in this topic, as older articles tend to gather more citations because they have been publicly available for longer (Belter, 2015).

The results found 95 distinct authors, and only one author authored 2 documents. To measure both the productivity and the citation impact of the publications (Hirsch, 2005), an authors' h-index was used based on the set of each scientist's most cited papers and the citations that they have received in other publications (Aria & Cuccurullo, 2017). These results, along with the top 5 most productive and most locally cited authors, are described in Table 2.

Table 1.
The total acrobatic gymnastics scientific production and citations count for each country.

Most productive countries	No. of articles	Frequency	SCP	MCP	MCP Ratio	Most cited countries	Total Citations
Spain	21	56.8%	18	3	14.3%	**Spain**	36
Poland	3	8.1%	3	0	0.0%	**Australia**	31
Portugal	3	8.1%	3	0	0.0%	**Poland**	10
Australia	2	5.4%	2	0	0.0%	**Portugal**	10
Italy	2	5.4%	2	0	0.0%	**Brazil**	3
Ukraine	2	5.4%	2	0	0.0%	**Canada**	3
Brazil	1	2.7%	1	0	0.0%	**Italy**	3
Canada	1	2.7%	0	1	100.0%	**Ukraine**	1
Germany	1	2.7%	1	0	0.0%	**United Kingdom**	1
United Kingdom	1	2.7%	1	0	0.0%	**Germany**	0
Total	37	100.0%	33	4	14.3%	**Total**	98

Legend: SCP: single-country publication; MCP: multiple-country publication and MCP_Ratio: the ratio between MCP and SCP (%).

Table 2.

The 5 most productive and locally cited authors and the Research Impact expressed as h-index.

Authors							
Most productive	**Affiliation**	**Articles**	**h-index**	**Most locally cited**	**Affiliation**	**Local citations**	**h-index**
Mercedes Vernetta-Santana	University of Granada	11	3	Águeda Gutierrez-Sanchez	University of Vigo	6	3
Águeda Gutierrez-Sanchez	University of Vigo	9	3	Yaiza Taboada-Iglesias	University of Vigo	6	3
Yaiza Taboada-Iglesias	University of Vigo	7	3	Mercedes Vernetta-Santana	University of Granada	6	3
Jesús Lopez-Bedoya	University of Granada	4	1	Roger Adams	University of Sydney	3	1
Diego Alonso-Fernandez	University of Vigo	3	1	Pablo Floría	Pablo de Olavide University	3	2

In Table 2, Mercedes Vernetta-Santana, from the University of Granada (Spain), is classified as the most productive author with 11 publications, followed by Águeda Gutierrez-Sanchez and Yaiza Taboada-Iglesias, both from the University of Vigo (Spain), with 9 and 7 publications, respectively. These three authors are the most locally cited, with 6 citations each and an h-index of 3. This measure was selected since it is the most widely used ranking metric, although its limitations are known and extensively reported (Kreiner, 2016). These results are evidence of domination of authors with Spanish affiliations. They are very different from those found in men's artistic gymnastics (Vargas & Capraro, 2020), where the most productive authors are from British (2 authors with 8 documents each), Brazilian and Slovenian universities (1 author, 5 documents for each country). Since the same study estimated the journals' h-index and not the authors' h-index, the results are not comparable in the present study.

Compared to other research topics, sports bibliometrics, sports psychology and women sports topics belong to a small-scale and small-range research field compared with other subject fields (Zheng & Liu, 2020), which is also the case for acrobatic gymnastics. Therefore, this h-index provides a low numerical distinction between authors, since they are limited to the number of documents published. A literature analysis of judo showed that an average researcher focusing exclusively on one field has limited possibility to achieve an h-index higher than 12 or 13, considering that the mean citation for a given paper is around this number, and goes even lower if a researcher is focused on a single sport (Peset Mancebo et al., 2013).

Finally, because bibliometric reviews in gymnastics disciplines are scarce, this is possibly the first time that the h-index is estimated for authors in acrobatic gymnastics, providing specific data for future comparisons.

Geography is an important factor for collaboration, and academics tend to

collaborate more frequently with those geographically near to them, particularly within their own country (Katz, 1994) or abroad (Luukkonen, Persson, & Sivertsen, 1992). It should be noted, though, that this situation has changed since the internet brought about global opportunites. In acrobatic gymnastics, cooperation normally takes place among different research institutions in the same country. When ordering the most productive institutions in acrobatic gymnastics, the Universities of Vigo, Granada, and Valencia are the leading Spanish research institutions, with 15, 10 and 3 documents published, respectively, and the Jerzy Kukuczka Academy of Physical Education and the Josef Pilsudski University of Physical Education are the leading Polish institutions, with 3 and 2 documents published, respectively.

The collaboration networks were assessed in three different fields: countries, affiliations and authors. Regarding the countries, the results revealed one single collaboration network between Spain and Ireland. In terms of affiliations, two networks were identified, one between the University of Granada and Vigo and another between the University of Limerick and Pablo de Olavide. Figure 3 presents the collaboration networks among authors from different institutions.

Figure 3 presents three different nerworks. Network 1 (upper-left corner) consists of 5 authors, including the 3 most productive and locally cited, affiliated with the University of Vigo and Granada, and two authors from Vigo and the Escuela Universitaria San Pablo CEU. Network 2 (lower-left corner) comprises two authors from the University of Granada. Network 3 (lower-right corner) consists of 2 authors from the Pablo de Olavide University (Seville), one fom San Isidoro University Center (Seville), and one from the University of Limerick (Ireland). While Networks 1 and 2 are connected, Network 3 is an exclusive collaboration between Seville (Spain) and Ireland. The lack of collaboration between all authors from distinct Spanish institutions may be a consequence of of different major areas of interest of each group. While Network 1 has investigated the anthropometric profile (Taboada-Iglesias et al., 2016; Taboada-Iglesias, Vernetta-Santana, Alonso-Fernandez, & Gutierrez-Sanchez, 2019; Taboada-Iglesias et al., 2017) and Network 2 investigated diverse subjects, such as injury incidence, jumping ability and body image (Ariza-Vargas, Salas-Morillas, Lopez-Bedoya, & Vernetta-Santana, 2021; Vernetta-Santana, Rojas, Montosa, & López-Bedoya, 2018; Vernetta, Montosa, & López-Bedoya, 2019), Network 3 has investigated balance abilities of acrobatic gymnasts as well as the pyramids balance (Floria et al., 2015; Gómez-Landero, Leal Del Ojo, Walker, & Floría, 2021; Leal Del Ojo et al., 2020).

The collaboration networks found have boosted publications in acrobatic gymnastics. The results revealed an average of 0.39 document per author, 2.57 authors per document and 3.57 co-authors per document. The divergence in the number of authors and co-authors per documents is related to the different ways used to count authors, e.g., if an author has written three publications, he/she will be counted only once in the authors per document ratio but he/she will be counted three times in the co-authors per document ratio (Aria et al., 2020). The collaboration index was 2.66, considering the total number of authors of multi-authored documents and the total number of multi-authored documents (Aria et al., 2020). The 5 most cited documents are described in Table 3.

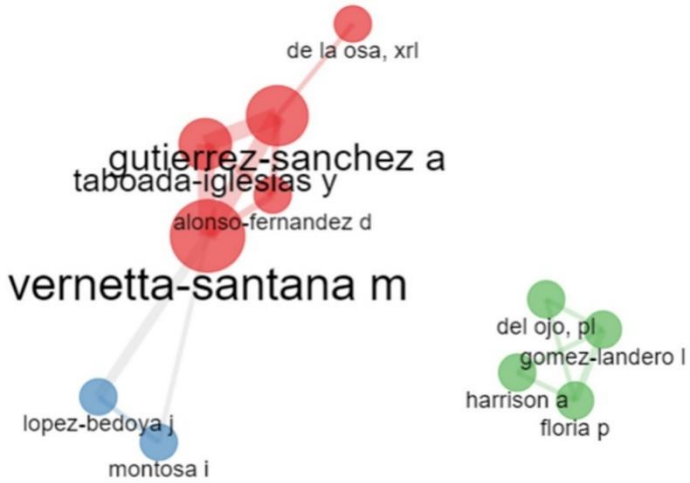

Figure 3. Collaboration networks among authors from different institutions and countries (Network 1: upper-left corner; Network 2: lower-left corner and Network 3: lower-right corner).

The most locally and globally cited document is focused on acrobatic gymnastics injuries (Purnell et al., 2010) with a clear advantage in terms of global citations (GC). However, higher GC indicates that it is mostly cited in articles outside the dataset used in this study (i.e., cited in non-acrobatic gymnastics articles). Considering the number of local citations (LC), its impact in the field is comparable to that of Taboada-Iglesias et al. (2017). This article, along with Taboada-Iglesias et al. (2015), has investigated the anthropometric profile and the remaining articles have evaluated the pyramid balance (Floria et al., 2015) or individual gymnasts' balance (Opala-Berdzik et al., 2018). The LC/GC ratio indicates that the most cited documents have more global than local citations, that is, these documents have more citations from documents outside of this data set (WoS and Scopus databases). The 3 local citations put Purnell's article on the same level as the other 3 listed articles, however, it has had a higher impact outside gymnastics. This may indicate that while the scientific community, relating to gymnastics in particular, may find such articles usefull, acrobatic gymnastics has not yet matured enough to recognise such articles as its seminal works.

The articles in this dataset have been published in 29 distinct journals. According to the Bradford's Law (Bradford SCE et al., 1953), there are core sources, this is, the journals that comprise most publications: for acrobatic gymnastics, there are 6 (Table 4). This table presents the most locally cited sources, i.e., how many times a source included in this collection has been cited by other sources also included in the collection (Aria & Cuccurullo, 2017).

The Retos and the Science of Gymnastics Journal are the primary sources, with 3 articles each. The remaining core sources published two articles each. The Retos journal focuses on physical education, sports and recreational activities, and the Science of Gymnastics Journal is gymnastics-specific. In contrast, the remaining sources publish documents with general themes and are highly reputable (e.g. Acta of Bioengineering and Biomechanics, and Sports Sciences for Health). There may be two reasons for this distinction: researchers published their studies in less reputable journals because the field is not consolidated enough for the big journals to be strongly interested, or the authors published in journals with topics closer to their interests.

Table 3

The 5 most cited documents, local and global citations and the respective ratio (%)

First author (Year)	Most cited documents	TC per year	LC	GC	LC/GC Ratio
Purnell et al. (2010)	Acrobatic Gymnastics injury: occurrence, site and training risk factors	2.33	3	28	10.71 %
Taboada-Iglesias et al. (2017)	Anthropometric profile in different event categories of Acrobatic Gymnastics	2.00	3	10	30.00 %
Floria et al. (2015)	Centre of pressure correlates with pyramid performance in Acrobatic Gymnastics	0.71	3	5	60.00 %
Taboada-Iglesias, Gutierrez-Sanchez, and Vernetta (2015)	Proportionality indices and body composition of elite Acrobatic Gymnasts	1.25	3	5	60.00 %
Opala-Berdzik et al. (2018)	Quiet standing postural sway of 10- to 13-year-old, national-level, female acrobatic gymnasts	2.00	1	6	16.67 %

Legend: TC – total citation; LC – local citation; GC – global citation; LC/GC ratio – ratio between LC and GC (%).

Table 4.

Core sources (Bradford's Law) and most locally cited sources

Core sources (Bradford's Law)	Articles	Most locally cited sources	Citations
Retos-Nuevas Tendencias En Educacion Fisica Deporte Y Recreacion	3	Gait & Posture	19
Science of Gymnastics Journal	3	Thesis	14
Acta of Bioengineering and Biomechanics	2	Journal of Human Kinetics	12
International Journal of Morphology	2	Journal of Sports Sciences	12
Sport Sciences for Health	2	Sports Medicine	12
Sports Biomechanics	2		

The only source with 2 publications in the last 2 years is the Science of Gymnastics Journal. The Acta of Bioengineering and Biomechanics and Sports Biomechanics published one document in 2021 and in 2020, respectively. The remaining journals published acrobatic gymnastics-related articles sporadically, i.e., both the International Journal Of Morphology and Sport Sciences For Health published 2

documents in 2015, and in 2018 and 2019, respectively. Finally, the Retos published one article per annum between 2017 and 2019.

Regarding the citations, the most locally cited sources are different from the core sources (Table 4). Nineteen documents cited Gait & Posture, the most cited source, followed by Thesis, with 14 citations. The remaining most locally cited sources indicate that the gymnastics researchers cited high quality sources. As stated previously, there are different reasons to cite an article, namely, providing background reading, substantiating claims, authenticating data and classes of facts, and naming original publications in which an idea or concept was first discussed (Garfield, 1970).

For the conceptual structure analysis, 119 author's keywords were considered. The thematic map (Figure 4) presented below was created to define four themes, according to the quadrant in which they are placed (Cahlik, 2000; Callon, Courtial, & Laville, 1991; Coulter, Monarch, & Konda, 1998; Courtial, 1994; He, 1999): 1) upper-right quadrant: motor-themes; 2) lower-right quadrant: basic themes; 3) lower-left quadrant: emerging or declining themes, and 4) upper-left quadrant: very specialized/niche themes.

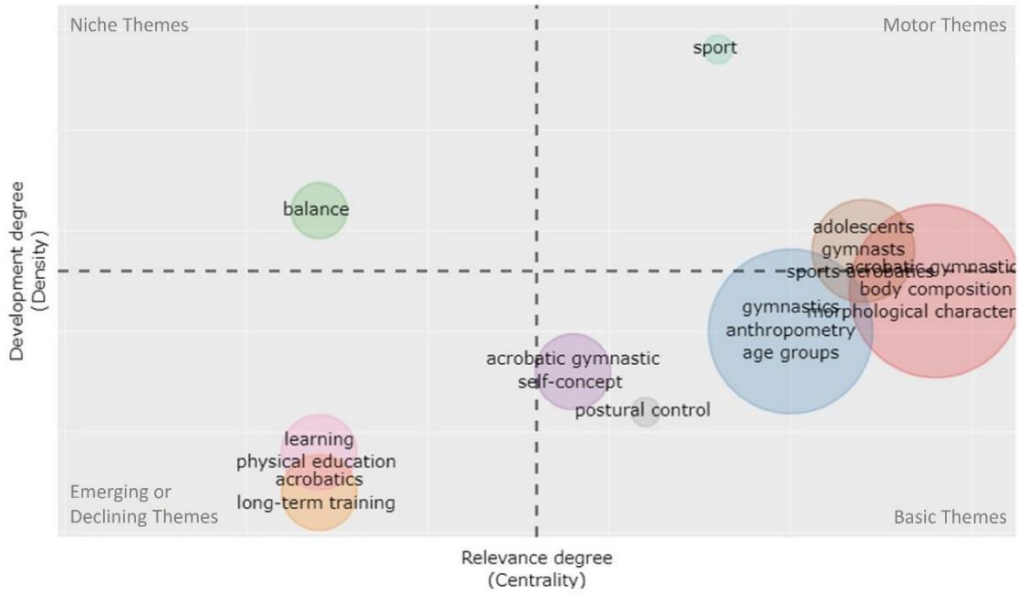

Figure 4. Thematic map for acrobatic gymnastics scientific research

Interpretation of each theme placement within the thematic map is essential to characterize each theme in terms of relevance (centrality) and development (density), according to the author keywords used in the documents within this data set (Figure 4). For the Motor Themes, 1) they are usually both well developed and important for a research field structuring given that they present strong centrality and high density, and 2) they are externally related to concepts applicable to other themes that are conceptually related (Cobo, López-Herrera, Herrera Viedma, & Herrera, 2011). Motor themes in acrobatic gymnastics are described as sport, refering to sports sciences and adolescent gymnasts from sports acrobatics.

The basic themes of this gymnastics discipline consist of self-concept, postural control, anthropometric characteristics in different age groups, and gymnasts' morphological characteristics, including body composition, which is positioned roughly in the middle, between the motor and the basic theme. A few studies have

investigated self-concept in the context of acrobatic gymnastics programs in physical education classes to promote team work and collaboration between students (López de la Osa & Gutiérrez-Sánchez, 2015; Xoana Reguera López, Gutiérrez-Sánchez, & Portela-Pino, 2016).

The main area that has contributed to the postural control research is Sports Biomechanics. Studies underline the need to employ comprehensive measuring techniques to provide a detailed kinematic and dynamic analysis to understand how the centre of pressure displacement is countered by continuous postural control of the two gymnasts who form the pyramid, having significant practical implications for training (Floria et al., 2015). Since the anthropometric profile has been investigated a lot (Silva, Silva, & Luemba, 2020; Taboada-Iglesias et al., 2016; Taboada-Iglesias et al., 2019; Taboada-Iglesias et al., 2017), the thematic map suggests that this basic theme is shifting to a motor theme.

The lower-left quadrant indicates that the learning process in physical education classes of acrobatic gymnastics and long-term training are becoming either an emerging or declining theme, suggesting that this area is both weakly developed and marginal since the themes in this quadrant have low density and low centrality (Cobo et al., 2011). While some studies investigated the learning process in physical education classes (Bores-Calle, Escudero, & Bores-Garcia, 2020; Gaudreau, Louvet, & Kljajic, 2019; Ramos, Ruiz, & Molina, 2015) and long term-training in acrobatic gymnastics (Bachinska, 2016; Bachinskaya, 2015), the results sugest that these subjects are declining in terms of significance.

The upper-left quadrant shows that balance is a specialized/niche theme. Sports Biomechanics is the main area responsible for analysing acrobatic gymnastics individual balance abilities (Opala-Berdzik, Głowacka, & Juras, 2021; Opala-Berdzik et al., 2018), and assessment of skill-specific balance positions such as the handstand (Sobera, Serafin, & Rutkowska-Kucharska, 2019) and the headstand (Gómez-Landero et al., 2021).

Regarding balance control in acrobatic gymnastics pyramids, only two studies were found (Floria et al., 2015; Leal Del Ojo et al., 2020). Due to its importance for performance, more studies are needed to understand balance control when two or more gymnasts stand together and form pyramids (Leal Del Ojo et al., 2020). This indicates a clear lack of attention for the specifics of this gymnastics discipline. Although balance is considered a major topic for investigation, there has been a lack of interest for the pyramids balance, a major feature of acrobatic gymnastics.

The main limitation of this work is that it does not incorporate high volumes of information. Since this is a modern gymnastics discipline in its preliminary developmental phase, the inclusion of resources from two databases was a strategy to address this limitation. The most challenging phase was the manual selection of articles. Since terms such as "acrobatic elements" and "acrobatic exercises" are frequently misused in articles pertaining to other gymnastic disciplines, a manual selection was required, which is not ideal. We would also like to highlight the limitation of using search keys to query databases. While we selected a generic approach to the term "gymnastics", changing two characters in a search key can affect the outcome. For instance, using "gymnastic*" instead of "gymnast*" may result in missing potentially relevant works, such as Taboada-Iglesias, Abalo-Nunez, Vernetta-Santana, & Gutierrez-Sanchez (2020). Although unfortunate, some articles are always left out of reviews due to the database or the search key used. In this manuscript, we present the results obtained with our search keys. Additionally, more advanced analysis, such as co-citation networks, were not conducted since the amount of information is not sufficient to

do so. This bibliometric analysis provides a static picture of the acrobatic gymnastics field development. Only a systematic review can provide a more detailed analysis, as it is the case for systematic reviews focused on biomechanical research methods used in acrobatic gymnastics to date (Leite et al., 2023). We hope that this bibliometric analysis provides tools for accurate use of terms distinguishing each gymnastics discipline.

CONCLUSIONS

The bibliometric data from this study present the first insight into the state and dynamics of publications of articles on acrobatic gymnastics. The results have shown that 2015 was a milestone year for scientific research in acrobatic gymnastics since it marked the beginning of continuous publication by Spanish authors, followed by those from Poland and Portugal. In terms of collaboration, countries are generally focused on their own territory and there is a limited scientific interaction between different nations. Only one such collaboration network between two countries was identified, namely betwen Spain and Ireland. Spanish and Polish universities are the leading research institutions publishing in this sport. This work may serve as a reference for future studies in acrobatic gymnastics, and balance has been identified as one of the key specialization topics of investigation. However, there has been a lack of interest in the pyramids balance, which is a major feature of acrobatic gymnastics.

ACKNOWLEDGMENTS

This work was supported by the Fundação para a Ciência e a Tecnologia, I.P. (FCT) under Grant number 2021.06653.BD.

No potential conflict of interest was reported by the author(s).

REFERENCES

Aria, M., & Cuccurullo, C. (2017). bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics, 11*(4), 959-975. doi:https://doi.org/10.1016/j.joi.2017.08.007

Aria, M., Misuraca, M., & Spano, M. (2020). Mapping the Evolution of Social Research and Data Science on 30 Years of Social Indicators Research. *Social Indicators Research, 149*(3), 803-831. doi:https://doi.org/10.1007/s11205-020-02281-3

Ariza-Vargas, L., Salas-Morillas, A., Lopez-Bedoya, J., & Vernetta-Santana, M. (2021). Perception of body image in adolescent participants and non-participants in acrobatic gymnastics. *Retos-Nuevas Tendencias En Educacion Fisica Deporte Y Recreacion*(39), 71-77. Retrieved from https://doi.org/10.47197/retos.v0i39.78282

Bachinska, N. (2016). Dynamics of indicators of general and special physical training of acrobats in the process of long-term perfecting. *Science and Education*(4), 100-+.

Bachinskaya, N. V. (2015). Features of construction of structures in long-term training acrobatics at the modern stage. *Physical Education of Students, 19*(1), 3-10. doi:https://doi.org/10.15561/20755279.2015.0101

Belter, C. W. (2015). Bibliometric indicators: opportunities and limits. *Journal of the Medical Library Association: JMLA, 103*(4), 219-221. doi:https://doi.org/10.3163/1536-5050.103.4.014

Bores-Calle, N. J., Escudero, A., & Bores-Garcia, D. (2020). Teaching Approaches to Learn Theoretical Contents in Physical Education: A Study about Contour Lines. *International Journal of Environmental Research and Public Health, 17*(22). doi:https://doi.org/10.3390/ijerph17228599

Bradford SCE, Egan M, & Shera JH. (1953). *Documentation* (2nd ed.): London, United Kingdom: Crossby Lockwood.

Cahlik, T. (2000). Comparison of the Maps of Science. *Scientometrics, 49*, 373-387. doi:https://doi.org/10.1023/a:1010581421990

Callon, M., Courtial, J. P., & Laville, F. (1991). Co-word analysis as a tool for describing the network of interactions between basic and technological research: The case of polymer chemsitry. *Scientometrics, 22*(1), 155-205. doi:https://doi.org/10.1007/BF02019280

Campbell, R. A., Bradshaw, E. J., Ball, N. B., Pease, D. L., & Spratford, W. (2019). Injury epidemiology and risk factors in competitive artistic gymnasts: a systematic review. *British Journal of Sports Medicine, 53*(17), 1056-1069. doi:https://doi.org/10.1136/bjsports-2018-099547

Ciomaga, B. (2013). Sport management: A bibliometric study on central themes and trends. *European sport management quarterly, 13*(5), 557-578. doi:https://doi.org/10.1080/16184742.2013.838283

Cobo, M. J., López-Herrera, A. G., Herrera Viedma, E., & Herrera, F. (2011). An approach for detecting, quantifying, and visualizing the evolution of a research field: A practical application to the Fuzzy Sets Theory field. *J. Informetrics, 5*, 146-166. doi:https://doi.org/10.1016/j.joi.2010.10.002

Coulter, N. S., Monarch, I., & Konda, S. L. (1998). Software Engineering as Seen through Its Research Literature: A Study in Co-Word Analysis. *J. Am. Soc. Inf. Sci., 49*, 1206-1223. doi:https://doi.org/10.1002/(SICI)1097-4571(1998)49:13%3C1206::AID-ASI7%3E3.0.CO;2-F

Courtial, J. (1994). A coword analysis of scientometrics. *Scientometrics, 31*(3), 251-260. doi:https://doi.org/10.1007/BF02016875

Fédération Internationale de Gymnastique. (2020). Acrobatic Gymnastics: Presentation. *Fédération Internationale de Gymnastique.* Retrieved from https://www.gymnastics.sport/site/pages/disciplines/pres-acro.php

Floria, P., Gomez-Landero, L. A., & Harrison, A. J. (2015). Centre of pressure correlates with pyramid performance in acrobatic gymnastics. *Sports Biomech, 14*(4), 424-434. doi:https://doi.org/10.1080/14763141.2015.1084032

Fonseca, P., Goethel, M., Vilas-Boas, J. P., Gutierres, M., & Correia, M. V. (2021). A Bibliometric Analysis of Intraoperative Neuromonitoring in Spine Surgery. *World Neurosurgery, 154*, 3-12. doi:https://doi.org/10.1016/j.wneu.2021.07.039

Garfield, E. (1970). Can Citation Indexing Be Automated? *Essasy of an Information Scientist, 1*, 84-90.

Gaudreau, P., Louvet, B., & Kljajic, K. (2019). The performance trajectory of physical education students differs across subtypes of perfectionism: A piecewise growth curve model of the 2 × 2 model of perfectionism. *Sport, Exercise, and Performance Psychology, 8*(2), 223-237. doi:https://doi.org/10.1037/spy0000138

Gómez-Landero, L. A., Leal Del Ojo, P., Walker, C., & Floría, P. (2021). Static balance performance differs depending on the test, age and specific role played in acrobatic gymnastics. *Gait Posture, 90*, 48-54. doi:https://doi.org/10.1016/j.gaitpost.2021.07.023

He, Q. (1999). Knowledge discovery through co-word analysis. *Library Trends, 48*, 133-159.

Katz, J. S. (1994). Geographical proximity and scientific collaboration. *Scientometrics, 31*(1), 31-43. doi:https://doi.org/10.1007/BF02018100

Kreiner, G. (2016). The Slavery of the h-index—Measuring the Unmeasurable. *Frontiers in Human Neuroscience, 10*(556).

doi:https://doi.org/10.3389/fnhum.2016.00556

Leal Del Ojo, P., Floría, P., Harrison, A. J., & Gómez-Landero, L. A. (2020). Effects of task difficulty on centre of pressure excursion and its inter-trial variability in acrobatic gymnastics pyramid performance. *Sports Biomech*, 1-16. doi:https://doi.org/10.1080/14763141.2020.1770322

Leite, I., Fonseca, P., Ávila-Carvalho, L., Vilas-Boas, J. P., Goethel, M., Mochizuki, L., & Conceição, F. (2023). Biomechanical Research Methods Used in Acrobatic Gymnastics: A Systematic Review. Biomechanics, 3(1), 52-68. doi:https://doi.org/10.3390/biomechanics3010005

Lindahl, J., Stenling, A., Lindwall, M., & Colliander, C. (2015). Trends and knowledge base in sport and exercise psychology research: a bibliometric review study. *International Review of Sport and Exercise Psychology, 8*(1), 71-94. doi:https://doi.org/10.1080/1750984X.2015.1019540

López de la Osa, X. R., & Gutiérrez-Sánchez, Á. (2015). Implementation of acrobatic gymnastics in Secondary Education for the improvement of self-concept. *RETOS-Neuvas Tendencias en Educacion Fisica, Deporte y Recreacion*(27), 114-117. doi:https://doi.org/10.47197/retos.v0i27.34359

Luukkonen, T., Persson, O., & Sivertsen, G. (1992). Understanding Patterns of International Scientific Collaboration. *Science, Technology, & Human Values, 17*(1), 101-126. doi:https://doi.org/10.1177/016224399201700106

Opala-Berdzik, A., Głowacka, M., & Juras, G. (2021). Postural sway in young female artistic and acrobatic gymnasts according to training experience and anthropometric characteristics. *BMC Sports Sci Med Rehabil, 13*(1), 11. doi:https://doi.org/10.1186/s13102-021-00236-w

Opala-Berdzik, A., Glowacka, M., Wilusz, K., Kolacz, P., Szydlo, K., & Juras, G. (2018). Quiet standing postural sway of 10-to 13-year-old, national-level, female acrobatic gymnasts. *Acta of Bioengineering and Biomechanics, 20*(2), 117-123. doi:https://doi.org/10.5277/abb-01060-2017-02

Peset Mancebo, M. F., Ferrer Sapena, A., Villamón Herrera, M., González Moreno, L. M., Toca Herrera, J.-L., & Aleixandre Benavent, R. (2013). Scientific literature analysis of Judo in Web of Science. *Archives of Budo, 9*(2), 81-91.

Prassas, S., Kwon, Y. H., & Sands, W. A. (2006). Biomechanical research in artistic gymnastics: a review. *Sports Biomechanics, 5*(2), 261-291. doi:https://doi.org/10.1080/14763140608522878

Prieto, J., Gómez, M.-Á., & Sampaio, J. (2015). A bibliometric review of the scientific production in handball. *Cuadernos de Psicología del Deporte, 15*(3), 145-154. doi:https://doi.org/10.4321/S1578-84232015000300014

Purnell, M., Shirley, D., Nicholson, L., & Adams, R. (2010). Acrobatic gymnastics injury: Occurrence, site and training risk factors. *Physical Therapy in Sport, 11*(2), 40-46. doi:https://doi.org/10.1016/j.ptsp.2010.01.002

Radecki, J., & Schonfeld, R. (2021). The Impacts of COVID-19 on the Research Enterprise: A Landscape Review. *Ithaka S+R.* Retrieved from https://doi.org/10.18665/sr.314247.

Ramos, M. A. A., Ruiz, M. A. M., & Molina, G. M. (2015). The Educational Relevance of Gymnastics Skills: Teachers' Appraisals. *Apunts Educacion Fisica Y Deportes*(121), 28-35. doi:https://doi.org/10.5672/apunts.2014-0983.es.(2015/3).121.04

Sandström, U., & van den Besselaar, P. (2016). Quantity and/or Quality? The Importance of Publishing Many Papers. *Plos One, 11*(11), e0166149.

doi:https://doi.org/10.1371/journal.pone.0166149

Silva, M. R. G., Silva, H. H., & Luemba, T. (2020). Anthropometric profile of gymnasts participating in the european games 2015 in baku, azerbaijan. *Science of Gymnastics Journal, 12*(2), 187-193.

Sobera, M., Serafin, R., & Rutkowska-Kucharska, A. (2019). Stabilometric profile of handstand technique in male gymnasts. *Acta of Bioengineering & Biomechanics, 21*(1), 63-71. doi:https://doi.org/10.5277/ABB-01267-2018-02

Sterkowicz-Przybycien, K., & Gualdi-Russo, E. (2018). Evaluation of somatotype in artistic gymnastics competitors: a meta-analytical approach. *The Journal of sports medicine and physical fitness, 59*(3), 449-455. doi:https://doi.org/10.23736/S0022-4707.18.08332-9

Taboada-Iglesias, Y., Abalo-Nunez, R., Vernetta-Santana, M., & Gutierrez-Sanchez, Á. (2020). Morphological profile of Spanish female acrobatic gymnasts. *Med. Sport, 73*(2), 231-255. doi:https://doi.org/10.23736/S0025-7826.20.03529-2

Taboada-Iglesias, Y., Gutierrez-Sanchez, A., & Vernetta, M. (2015). Proportionality Indices and Body Composition of Elite Acrobatic Gymnasts. *International Journal of Morphology, 33*(3), 996-1001. doi:https://doi.org/10.4067/s0717-95022015000300030

Taboada-Iglesias, Y., Gutierrez-Sanchez, A., & Vernetta Santana, M. (2016). Anthropometric profile of elite acrobatic gymnasts and prediction of role performance. *Journal of Sports Medicine and Physical Fitness, 56*(4), 433-442. Retrieved from PMID: 25743542

Taboada-Iglesias, Y., Vernetta-Santana, M., Alonso-Fernandez, D., & Gutierrez-Sanchez, A. (2019). Anthropometric Specificity and Level of Participation in Acrobatic Gymnastics Based on Sex. *International Journal of Morphology, 37*(4), 1534-1540. doi:https://doi.org/10.4067/s0717-95022019000401534

Taboada-Iglesias, Y., Vernetta Santana, M., & Gutiérrez-Sánchez, Á. (2017). Anthropometric Profile in Different Event Categories of Acrobatic Gymnastics. *Journal of Human Kinetics, 57*(1), 169-179. doi:https://doi.org/10.1515/hukin-2017-0058

Vargas, P., & Capraro, A. (2020). The profile of the academic production on men's artistic gymnastics from the web of science and scopus. *Science of Gymnastics Journal, 12*(3).

Vernetta-Santana, M., Rojas, N., Montosa, I., & López-Bedoya, J. (2018). Application of tensiomyography to assess the muscle response in the lower limbs of acrobatic gymnasts. *European Journal of Human Movement, 40*, 96-110.

Vernetta, M., Montosa, I., & López-Bedoya, J. (2019). Lesiones en jóvenes gimnastas femeninas de acrobática de la élite nacional. *Revista Iberoamericana de Ciencias de la Actividad Física y el Deporte, 7*(3), 71-84. doi:https://doi.org/10.24310/riccafd.2018.v7i3.5542

Xoana Reguera López, d. l. O., Gutiérrez-Sánchez, Á., & Portela-Pino, I. (2016). Self-concept and Cooperative Work: Assessment of a Program. *International Journal of Assessment & Evaluation, 23*(1), 11-26. doi:https://doi.org/10.18848/2327-7920/CGP/v23i01/48382

Zheng, Y., & Liu, S. (2020). Bibliometric analysis for talent identification by the subject–author–citation three-dimensional evaluation model in the discipline of physical education. *Library Hi Tech*. doi:https://doi.org/10.1108/LHT-12-2019-0248

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Article received: 28.9.2022
Article accepted: 3.2.2023

RELATIONSHIP BETWEEN JUMPING-MOTION AND MUSCLE ACTIVITY DURING SOMERSAULT IN TRAMPOLINE: A CASE STUDY

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Original article *DOI:15.1.65-74*

Abstract

This study investigated the relationship between jumping-motion and muscle activity during somersaults on a trampoline. Participants were 10 trampoline athletes (3 high-level and 7 middle-level). As for the protocol, the athletes performed a jump continuation of the tucked backward somersault (Back) and the tucked forward somersault with half twist (Barani) on a trampoline. It was measured using an electromyogram (EMG) and video analysis. The jump was defined as "100 ms before touch" 100 ms before the subject landing on the trampoline bed; "Touch" at the moment of landing; "Lowest" at the moment of going down, and "Take off" at the moment of taking off. They were defined as "Before touch phase" from "100 ms before touch" to "Touch"; as "Down phase" from "Touch" to "Lowest", and as "Upward phase" from "Lowest" to "Take off". As a result, the trunk inclination angles of both the high- and middle-level participants regarding the Back (middle-level 4.3±1.3°, high-level 7.0±2.4°) and the Barani (middle-level 9.2±1.7°, high-level 9.4±1.7°) during the Lowest phase were forward. There were no significant differences. The EMG amplitude of the rectus abdominis ($p < 0.05$) during the Upward phase and the erector spinae ($p < 0.01$) during the Before touch phase were significantly higher in the high-level group. The trunk was inclined by using the erector spinae as in the high-level between Before 100ms touch and Lowest. Stabilization of the trunk by the activity of the rectus abdominis was the efficient movement of the lower extremity during the Upward phase.

Keywords *trampoline, backward somersault, forward somersault with half twist, electromyogram, take-off.*

INTRODUCTION

Improving jumping performance leads to higher movements on the trampoline. This directly affects the gymnast's score in trampolining as it can contribute to the performance score for total flight time (2022-2024 Code of Points Trampoline Gymnastics, [CoPTG] 2021). Coaches use the phrase "contracting your muscle" for general instruction in a jumping-motion. (Obayashi,1998). However, there is little evidence as to which muscle contracts at what timing. Previous studies on the muscle activity of the jumping-motion in trampolining reported that muscle activity in the lower extremity was observed before and after landing (Matsushima, et al., 2017; Matsushima, & Yano, 2018a; Matsushima, & Yano, 2018b; Song, Yao, & Sun, 2011).

However, extensive previous research on muscle activity in the jumping-motion from the ground reported that the mechanism of muscular activation started

with activity in the proximal muscles and then the distal muscles of the lower extremity (Arai, Ishikawa, & Ito, 2013; Fukashiro,1990; Mark L, 2018). One study suggested that the bi-articular muscle of the lower extremity related to the motion in the vertical jump is associated with cooperative muscular activity combining excitement and inhibition (Dennis, Melissa, & Meghan, 2016; Oshima, et al., 2005; Torikai, et al.,2003; Van Ingen Schenau, et al., 1985).

Despite progress in research using electromyogram (EMG) analysis of muscle activity in jumping movements from the ground, most jumping-motions on the trampoline have not been studied. There has been minimal progress in studies of somersault jumping-motions (Deborah, Eduardo, & Jorge, 2021; Mkaouer, et al., 2012). Therefore, the purpose of this study was to investigate the somersault jumping-motion in trampoline athletes of different levels using an electromyogram and video analysis.

METHODS

Ten trampoline athletes (3 "high-level" Japanese national team members and 7 "middle-level") were recruited as participants. The high-level Japanese national team members constituted 1 male and 2 females (age 20.3±0.9 years, body mass 55.7±5.6 kg, height 165.5±6.0 cm, athletic career 12.7±3.9 age), and the middle-level constituted 4 males and 3 females (age 19.1±1.6 years, body mass 59.7±8.9 kg, height 163.1±6.9 cm, athletic career 5.9±2.1 age).

This study was conducted after obtaining approval from the Research Ethics Screening Committee of Mukogawa Women's University (Approval Number No, 13-52). Informed consent was obtained from the participants and their guardians prior to the study. Additionally, they gave their written consent.

The EUROTRAMP trampoline Premium 4 × 4, officially recognized by the International Gymnastics Federation, was used for the experiment. For the trial protocol, the participants performed 5 preliminary jumps from stillness at the standing position, followed by the tucked backward somersault (Back), then the tucked forward somersault with half twist (Barani). The Back and the Barani were repeated alternately 5 times each. Therefore, the participants performed 10 somersaults after the 5 preliminary jumps. The trial protocol was decided on base of the Code of Points for trampoline gymnastics (2022-2024 Code of Points Trampoline Gymnastics, [CoPTG] 2021). A trampoline athlete must perform 10 elements continuously. Since most athletes alternate between backward and forward somersaults, a continuous somersault method was adopted in the study.

Participants were instructed to jump as high as possible at maximum effort. Each experimental session started with a standardized warm-up protocol to ensure the participants performed the vertical jumps at maximum effort without any risk of injury.

After each experiment, the isometric maximal voluntary contraction (MVC) of each muscle was measured by the manual muscle testing (MMT) method (Hislop, & Montgomery, 2007).

The experimental setup was connected to a pressure sensor load cell (LUX-B-2KN-ID, Kyowa Electronics, Japan, 1000Hz sampling) between the spring and flame of the trampoline side center, and marked the participant's landing point (Touch), the lowest point (Lowest), and the leg take-off point (Take-off) on the trampoline.

Eight muscles were measured in total: sternocleidomastoid (SCN), trapezius upper part (TR), rectus abdominis (RA), erector spine (L4 level) (ES), rectus femoris muscle (RF), biceps femoris long head (BF), tibialis anterior (TA), and gastrocnemius (GL). Wireless electrocardiographs were attached in reference to Aldo (Aldo, 2007). An electrocardiogram of each participant was recorded using a wireless electrocardiograph (multi-channel

telemetering system WEB-7000, Nihon Kohden, Japan). The experiment derived EMGs with a 1000Hz sampling frequency. The date signal stored in the memory card was transferred and stored on a personal computer (PC).

Moreover, participants were recorded from the side while they performed jumping using a high-speed camera (EX-F1, CASIO, Japan). The camera was set up at a heigh of 5.550m equivalent to the trampoline bed, and at 1.155 m from the center of the trampoline bed. The light-emitting diode (LED) lamp projected light on the high-speed camera at a range that did not influence the jumping. All data were synchronized.

To synchronously record the EMG and the load cell signals, the signal of the LED lamp was recorded.

The coordinate axis in the two-dimensional motion analysis assumed the horizontal axis as the X-axis and the vertical axis as the Y-axis. The reference point and standard length of the calibration assumed both ends (4.280m) of the trampoline bed to be on the X-axis.

The jump was divided into four stages and three phases and analyzed accordingly (Figure 1). The four stages were defined as "100 ms before touch" - 100 ms before the subject's landing on the trampoline bed; "Touch" at the moment of landing; "Lowest" at the moment of going down, and "Take off" at the moment of taking off. They were defined as "Before touch phase" from "100 ms before touch" to "Touch"; as "Down phase" from "Touch" to "Lowest", and as "Upward phase" from "Lowest" to "Take off".

The EMG data collected during each action were converted through a band-pass filter (20–500 Hz) and full-wave, rectified to the EMG amplitude of each jump per unit time. The data were normalized using the EMG amplitude (%MVC) measured for each muscle during the time in which the muscle exerted MVC.

The video recordings of the participants' bodies were used to digitize the acromion, greater trochanter, knee joint fissure, lateral malleolus, calcaneus, and fifth head of metatarsal bone by using two-dimensional analysis software (Frame-DIAS IV, DKH, Japan).

The hip joint angle was defined as the angle formed by the line which connects the greater trochanter from the acromion and the line which connects the knee joint fissure from the greater trochanter. The knee joint angle was defined as the angle formed by the line which connects the knee joint fissure from the greater trochanter and the line which connects the lateral malleolus from the knee joint fissure. The ankle joint angle was defined as the angle formed by the line which connects the calcaneus from the lateral malleolus and the line which connects the fifth head of metatarsal bone from the calcaneus. Moreover, each joint angle was calculated using the anatomical position starting at 0°. As for the trunk inclination angle, it was defined as the angle formed by the line which connects the greater trochanter from the acromion, and the line which connects vertically upward from the greater trochanter (Figure 2). The trunk inclination angle was assumed positive (+) in forward inclination, and negative (−) in backward inclination. The data were analyzed using each joint and trunk inclination angle in the jump with the longest flight time.

The mean value and standard deviation were obtained for the activity level of each muscle, joint, and trunk inclination angle. The Mann–Whitney U test was used to analyze the data. In each case, the significance level was set at 0.05.

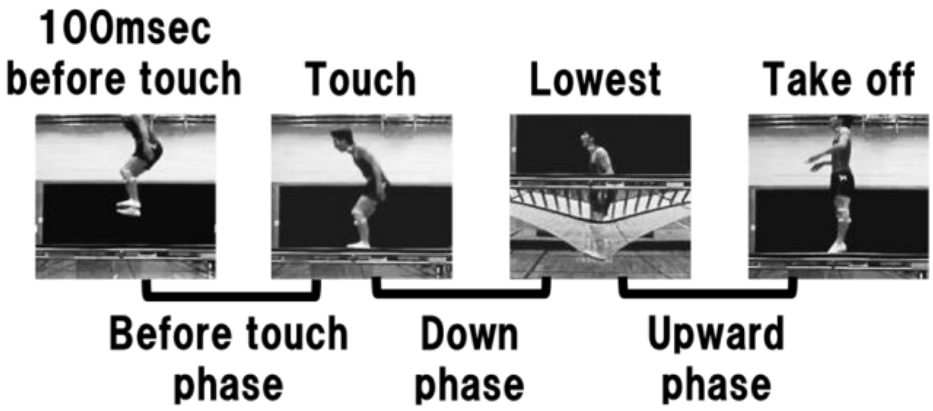

*Figure 1***.** Definition of the jump phase.

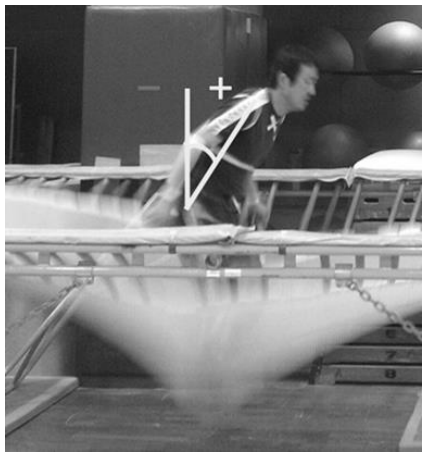

*Figure 2***.** Definition of trunk angle.

RESULTS

In the Back, the high-level participants were significantly higher than the middle-level participants in the ankle joint dorsiflexion angle during Before 100 ms of touch ($p < 0.01$), knee joint flexion angle during Before 100 ms of touch ($p < 0.05$), and hip joint flexion angle during Before 100 ms of touch ($p < 0.01$) and Lowest ($p < 0.05$) (Figure 3).

In the Barani, the high-level participants were significantly higher than the middle-level participants in the ankle joint dorsiflexion angle during Before 100 ms of touch ($p < 0.05$), knee joint flexion angle during Before 100 ms of touch, and Touch ($p < 0.01$), and hip joint flexion angle during Take-off ($p < 0.01$) (Figure 4).

In the Back, the change in the trunk inclination angle between Before 100ms touch and Lowest was significantly higher for the high-level participants (57.1±5.5°) than the middle-level (33.2±6.4°) ($p = 0.03$).

In the Barani, the change in the trunk inclination angle between Before 100ms touch and Lowest was higher in the high-level participants (44.1±2.5°) than the middle-level (28.8±6.8°), but there was no significant difference.

The trunk inclination angles of both levels in the Back (Middle-level 4.3±1.3°, high-level 7.0±2.4°) and the Barani (Middle-level 9.2±1.7°, high-level 9.4±1.7°) during Lowest were forward. There were no significant differences between the Back and the Barani.

The ES of EMG amplitude(%MVC) of the high-level participants was significantly higher than the middle-level ($p < 0.01$), and BF of the middle-level was recognized as

significantly higher than the high-level ($p < 0.01$) during Before touch phase in the Back (Figure 5).

In the Back, the BF of EMG amplitude (%MVC) of the middle-level participants was significantly higher than the high-level during the Down phase ($p < 0.05$) (Figure 6).

In the Back, the BF of EMG amplitude (%MVC) of the middle-level participants was recognized as significantly higher than the high-level ($p < 0.01$) during the Upward phase (Figure 7).

In the Barani, the ES of EMG amplitude (%MVC) of the high-level participants was significantly higher than the middle-level, and BF of middle-level was significantly higher than the high-level ($p < 0.01$) during the Before touch phase (Figure 8).

In the Barani, the BF of EMG amplitude (%MVC) of the middle-level participants was significantly higher than the high-level ($p < 0.01$) during the Down phase (Figure 9).

In the Barani, the GL ($p < 0.01$) and RA ($p < 0.05$) of EMGs amplitude (%MVC) of the high-level participants was significantly higher than the middle-level, and BF of middle-level was significantly higher than high-level ($p < 0.01$) during the Upward phase (Figure 10).

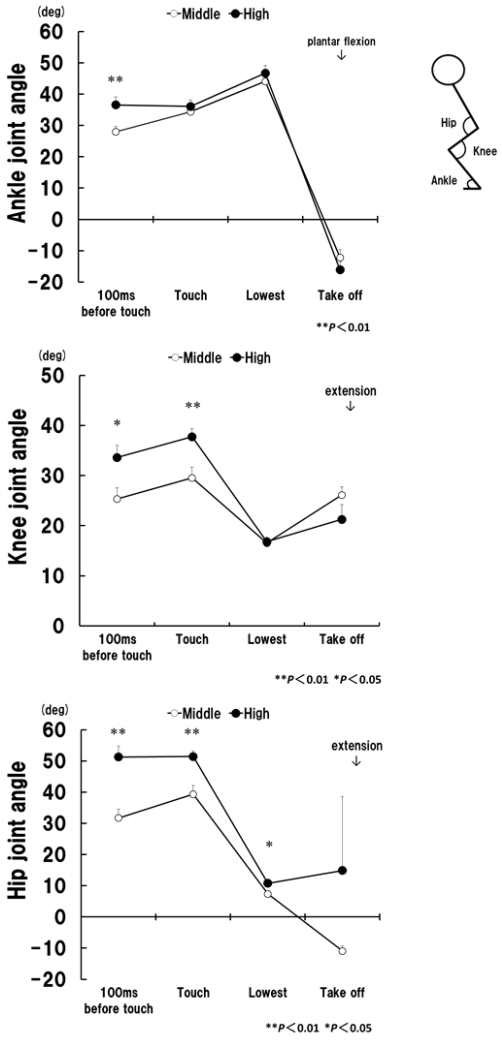

Figure 3. Differences between the middle and high-levels in the leg joint angles of jump phases of the Back. Ankle, knee, and hip joint angles were shown from the top to bottom.

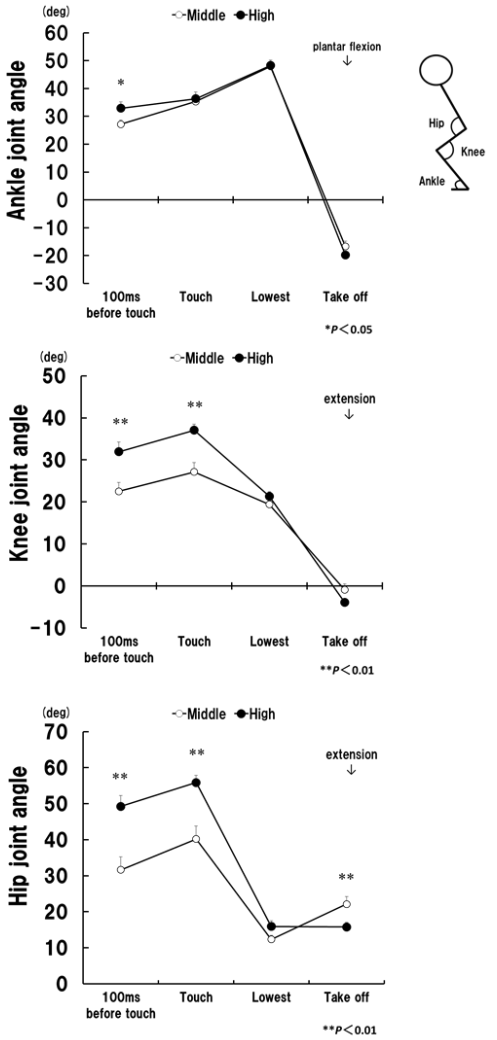

Figure 4. Differences between the middle and high-levels in the leg joint angles of jump phases of the Barani. Ankle, knee, and hip joint angles were shown from the top.

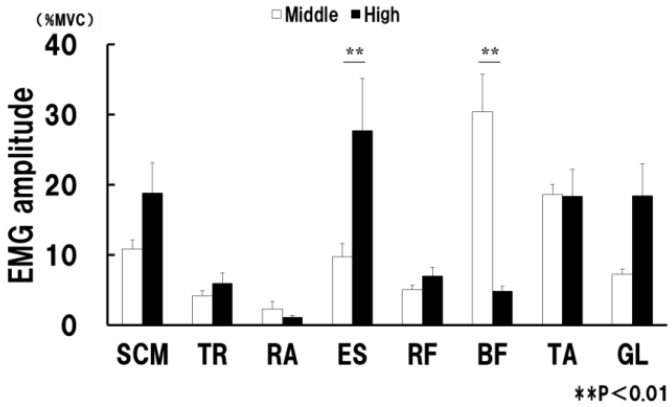

*Figure 5***.** Differences between the middle and high-level of EMGs amplitude (%MVC) during Before touch phase in the Back.

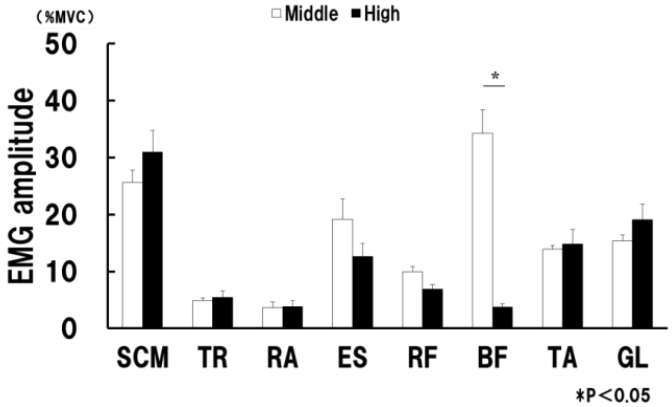

*Figure 6***.** Differences between the middle and high-level of EMGs amplitude (%MVC) during Down phase in the Back.

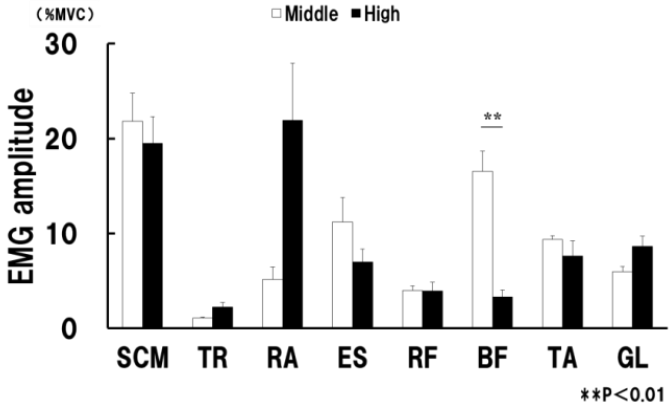

*Figure 7***.** Differences between the middle and high-level of EMGs amplitude (%MVC) during the Upward phase in the Back.

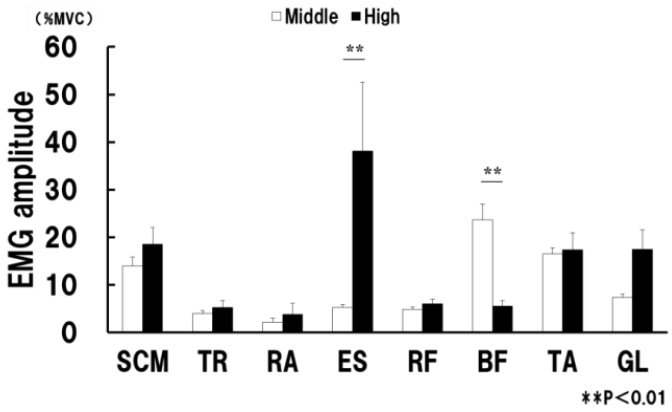

*Figure 8***.** Differences between the middle and high-level of EMGs amplitude (%MVC) during Before touch phase in the Barani.

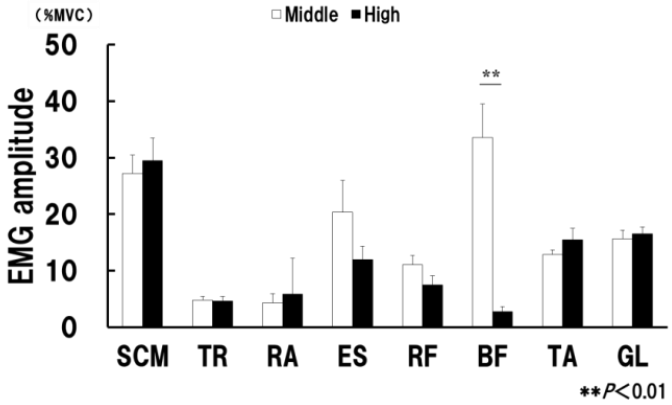

*Figure 9***.** Differences between the middle and high-level of EMGs amplitude (%MVC) during Down phase in the Barani.

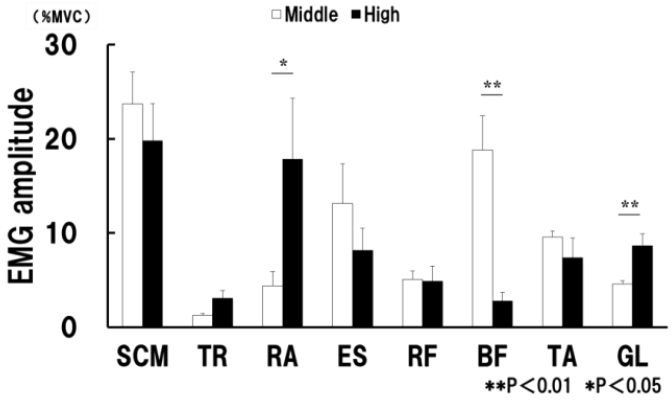

*Figure 10***.** Differences between the middle and high-level of EMGs amplitude (%MVC) during the Upward phase in the Barani.

DISCUSSION

The time of flight score signifies the total time the trampoline athlete stays in the air during a routine and is added to the score in all routines (2022-2024 Code of Points Trampoline Gymnastics, [CoPTG] 2021). The Back and the Barani are fundamental somersault jumps in routines (Dave, et al.,2015; Wojciech, & Adam, 2001). According to the results of this study, ES of EMG amplitude (%MVC) of both the Back and the Barani jumps was significantly higher in the high-level participants than in the middle-level group during the Upward phase (Figure 5, 8). In addition, the trunk was inclined backward so that even changes in the trunk inclination angle between Before 100ms touch and Lowest were evident. It was suggested that it was for the jumping-motion with the vertical posture. Therefore, the trunk in the vertical posture at Lowest was examined to see if it was controlled by using the backward trunk posture with activity of the ES.

At take-off, the knee joint angle was flexed in the Back, and the hip joint angle was extended in the Barani (Figure 3, 4). In previous studies, the knee and hip joint movements changed according to the somersault type (Dave, et al.,2015; Deborah, et al., 2021; Wojciech, & Adam, 2001). However, this study suggests that the RA of EMG amplitude (%MVC) of high-level participants is significantly higher during the Upward phase in both the Back and the Barani (Figure 7, 10). Since it is grounded on the trampoline, during a jumping-motion, movement of the lower extremity is a closed kinetic chain (CKC). However, it shifted gradually to an open kinetic chain (OKC) during the Take-off from the Lowest. Movement of the lower extremities in OKC requires a fixed trunk. According to Kondo and Iwata (Kondo, & Iwata, 2011), when the pelvis and lower extremities enable a certain movement, the trunk muscle activity can be activated. Therefore, although there are different motions of the lower extremities between the Back and the Barani, a significant activity of the RA in the high-level group showed that a trunk was stabilized and the lower extremity moved efficiently. The findings suggested that it was important in the jumping-motion of somersaults to ensure ES activity during the Before touch phase and RA activity during the Upward phase.

CONCLUSION

From the results, this study suggests that jumping-motion on a trampoline can improve. This study investigated the relationship between jumping-motion and muscle activity during a somersault in trampoline athletes.

The trunk was inclined by using the ES in the high-level athletes between Before 100ms touch and Lowest.

Stabilization of the trunk by activity in the RA was associated with efficient movement of the lower extremity during the Upward phase.

The participants performed somersault of the Back and the Barani in this study. In addition, the feedback recorded with the video camera provided a motion check since the aerial posture is reflected in one's performance. However, the activity of muscles which could not be ascertained was the one factor that influenced performance in the video analysis. These results will be established with the instruction data for activating a specific muscle at suitable timing. These study findings should be further investigated to analyze various somersaults and twist motions in trampolining.

REFERENCES

2022-2024 Code Of Points Trampoline Gymnastics. (2021). Federation Internationale De Gymnastique.

Aldo O Perotto. (translation:Hakumori R). (2007). Anatomical guide for electromyographer—The limbs and

trunk—3rd ed. *Nishimura Company*, Tokyo.

Arai, A., Ishikawa, M. And Ito, A.(2013). Agonist-antagonist muscle activation during drop jumps. *European Journal of Sport Science*, 13(5): 490-498.

Dave, B., Fred, Y., Mike, H.(2015). Optimum technique for maximizing forward somersault rotation in trampolining. *33 International Conference of Biomechanics in Sports*, Poitiers, France.

Deborah, M, Eduardo, P and Jorge, J.(2021).Take-off Hip Extension Angle Influence on The Tucked Back Somersault Performance. *Science of Gymnastics Journal*, 13(2):203-209.

Dennis, L., Melissa, T. and Meghan, R.(2016). Actions of Two Bi-Articular Muscles of the Lower Extremity: A Review, *Clinical medical journal*, 8(7): 489–494.

Hasegawa, T. (1966).An Analytical Study on the Form of Tuck Back Somersault by Trampoline. *Tokyo Women Physical Education College J*.,1:40-45.

Hasegawa, T. and Obayashi, M. (1971). An Analytical Study on the Form of Foward Somersault and 1/2 twist by Trampoline. *Japanese Society of Physical Education*, 15(5):119.

Hislop, H.J. and Montgomery, J. (2007) Daniels and Worthingham's Muscle Testing: Techniques of Manual Examination. 8th Edition, *WB Saunders*, Philadelphia.

Fukashiro, S. (1990). Jump Science. *Taisyukan Company*, pp 18-19 , Tokyo.

Kondo, Y. and Iwata, M. (2011). Trunk Muscle Activities during Unilateral Straight Leg Raising —Comparison of Three Contralateral Leg Conditions—. *Rigakuryoho Kagaku*. 26(5):577-581.

Mark, L.(2018). Muscle coactivation: definitions, mechanisms, and functions. *Journal of Neurophysiol*, 120(1):88-104.

Matsushima, M. and Yano, S. (2018a). Relation between muscle activity during takeoff and landing positions in the trampoline straight jump. *Objectives of the Research Journal of Sports Performance*, 10: 15-26.

Matsushima, M. and Yano, S. (2018b). Difference between trampoline and rebound jumps during the down phase. *Journal of physical exercise and sports science*, 23(2): 133-138.

Matsushima, M. and Yano, S. (2018c). Difference between trampoline experts and non-experts regarding the take-off motion. *Physical Education and Sports Science*, 27: 39-48.

Matsushima, M., Nakanishi, M., Nakanishi, Y., Uesugi, Y., Yano, S. and Ito, T. (2017). Relationship between muscle activity and flight time during trampoline jump. *Physical Education and Sports Science*, 26: 31-36.

Mkaouer, B., Monem, J., Amara, S., Chaabèn, H. and Tabka, Z. (2012). Kinematic and Kinetic Analysis of Counter Movement Jump versus Two Different Types of Standing Back Somersault. *Science of Gymnastics Journal*. 4(3): 61-71.

Nakayama, A., Yuasa, K., Nakayama, M., Hosoi, T., Ueda, Y. and Saito, M. (1981). Biomechanical comparison of the Back somersault between male and female gymnasts. *Tyukyou U J*, 21(1):92-98.

Obayashi, M. (1998). TRAMPOLINE. *Dowa Company*, pp 2-3, Tokyo.

Obayashi, M. and Hasegawa, T. (1966). An Analytical Study on the Form of Tuck Back Somersault by Trampoline. *Japanese Society of Physical Education*. 10(2)2:230.

Oshima, T., Torikai, K., Fujikawa, T. and Momose, N. (2005). Jump Mechanism using Coordination Function of Bi-articular Muscle in Knee and Ankle Joint. *Transactions of the Japan society of mechanical engineers*. C 71(712):176-182.

Torikai, S., Oshima, T., Fujiwara, T., Kumamoto, M. and Momose, N. (2003). Effects of the Bi-Articular Gastrocnemius Muscle of Human on the Jump Movement of the Model. *Transactions of the Japan Society of Mechanical Engineers C*. 69(688): 3263-3268.

Song, Y., Yao, D., Sun W. (2011). Analsis about sEMG in the Process of Net-kicking of the Trampoline Athlete. *Journal of Beijing Sport University,* 34(2): 65-67.

Van Ingen Schenau GJ, Bobbert M F, Huijing P A & Woittiez R D.(1985). The instantaneous torque-angularvelocity releation in plantar flexion during jumping. *Med Sci Sports Exerc*, 17:422-426.

Wojciech, B. and Adam, C.(2001). Modeling and inverse simulation of somersaults on the trampoline. *Journal of Biomechanics,* 34:1619-1629.

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Article received: 26.12.2022
Article accepted: 11.1.2023

TIME COURSE OF CHANGES IN STRADDLE JUMP AND VERTICAL JUMP PERFORMANCE AFTER ACUTE STATIC STRETCHING IN ARTISTIC GYMNASTS

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Original article *DOI:15.1.75-85*

Abstract

The aim of the present study was to examine the time course of changes of the effects of static stretching on straddle jump, vertical jump height and flexibility after performing dynamic movements in artistic gymnasts. The study was participated by 14 female artistic gymnasts aged between 9 and 14. Vertical jump heights were measured using the New Test 2000 testing device. Flexibility measurement was performed with sit and reach flexibility test. Artistic gymnastics-specific jump movement was evaluated looking at the angle between lower extremities using the Dartfish motion analysis program. Baseline measurements taken before the standard warm-up and the measurements taken after static stretching were assessed. Four sets of gymnastics moves each lasting two minutes were performed. The tests were repeated after each set. Static stretching was found to affect vertical jump performance significantly. Significant differences were found between $Jump_2$ and $Jump_1$ ($p=0.01$), $Jump_2$ and $Jump_3$ ($p=0.03$), $Jump_2$ and $Jump_4$ ($p=0.01$), $Jump_2$ and $Jumop_5$ ($p=0.004$), and $Jump_2$ and $Jump_6$ ($p=0.009$). In flexibility-related changes, significant differences were found between $Reach_2$ and $Reach_3$ ($p=0.03$), and $Reach_2$ and $Reach_6$ ($p=0.006$). Static stretching was found to have no significant effect on the lower extremity straddle jump degree. In conclusion, although the static stretching protocol reduced vertical jump performance significantly, it did not affect the artistic gymnastics-specific jump move. The negative effects of static stretching on jump height approached the baseline value approximately 4 minutes later.

Keywords: *artistic gymnastics, static stretching, vertical jump, flexibility*

INTRODUCTION

Stretching protocols are widely used by many athletes in the warm-up period before exercise and competitions (Shrier, 2004; Booth, 2008). Flexibility is an important component for the development of many athletes. Therefore, stretching exercises are frequently used for improving flexibility (Stone, 2006). Stretching methods include static stretching (reaching the best possible stretching point and maintaining the position for a certain period of time), ballistic stretching (defined as the method reached by a rhythmic oscillation loading to the muscle's near-maximum stress point), Proprioceptive Neuromuscular Facilitation (PNF, a type of flexibility exercise which combines muscle contraction and relaxation with passive and

partner-assisted stretching), and dynamic stretching techniques (Amiri- Khorasani et al., 2010; Behm et al., 2001). Static stretching practices prior to exercise are believed to bring up better performance, reduce the risk of injury (Shellock, & Prentice, 1985; Cross, & Worell, 1999; Hartig, 1999) and increase the joint range of motion (Laban, 1962; Amiri- Khotasani, 2013). However, although static stretching is widely used, it is the most controversial technique with ever-changing views on its positive and negative aspects on muscle strength and power (Chaabene, Behm, Negra, & Granacher, 2019). Such controversial results can be explained by the different stretching times or intensities applied (>10 minutes) (Konrad, Reiner, Thaller, & Tilp, 2019). (Konrad, Reiner, Thaller, & Tilp, 2019). According to various findings, the intensity and duration of static stretching changes performance considerably, and prolonged static stretching causes losses in strength (Freitas et al., 2015; Magnusson, 1998). Static stretching has been found to have negative effects on maximal power performance (Jeni, & Sands, 2003). The change in the strength-speed relationship and decreased muscle tension indicate that static stretching impairs strength generation (Behm, & Button, 2001; Power et al., 2004). As a result of the inverse myotatic reflex on the tendon stretched with the muscle tension, it is related to inhibiting the muscle to which the tendon is connected. The inverse myotatic reflex is initiated by the Golgi tendon organ. The degree to which the Golgi tendon organ influences the motor unit depends on the frequency of the stimulus. (Fox et al., 1988). Thus, it causes difficulty in sports that require maximal power and strength during exercise, like jumping and running (Jeni et al., 2003; Young, 2001; Fletcher, 2004). On the other hand, it is reported that static stretching performed for less than 30 seconds is effective in minimizing the negative outcomes of stretching, and beneficial for the joint range of motion (ROM) in well-trained athletes, while high intensity and long-duration static stretching may play a critical role by causing impairments in strength outputs (Behm et al., 2011). After a static stretching protocol of 90 seconds, athletes' hip ROM improved, and it had no statistically significant effect on jump heights 2 minutes after stretching. This indicated that long-duration flexibility training and the increased musculotendinous pliability could prevent the transient decrease in strength and power (Papia et al., 2018).

Although many studies have examined the negative effects of static stretching on performance, no study has been found that would look into how long this effect lasts during training or competition. In addition, physical exercise affects the balance of the homeostasis. Muscles that contract during exercise produce force and heat. Physical exercise is actually a form of mechanical energy. This produced energy will deplete the energy stocks in the body. Depending on the form of exercise, sooner or later, fatigue and exhaustion will occur (Ament & Verkerke, 2009). Therefore, it is important to determine whether the effects are due to fatigue or to static stretching. The aim of the present study was to examine the time course of changes of the effects of static stretching on artistic gymnastics-specific jump moves, vertical jump height and flexibility in artistic gymnasts.

The hypotheses of our study: Static stretching increases flexibility. It negatively affects vertical jump height and straddle jump performance.

The present study is important as we think the negative effects of static stretching may disappear after a while.

METHODS

14 female (age: 10.78 ± 1.80, weight (kg): 32.25 ± 8.62, height (cm): 136.75± 11.07) artistic gymnasts participated in the study. They were aged 9-14, had at least 4 years of sport experience and had no injury or disease in the last 6 months prior to the study. The athletes took the tests in the

Gymnastics Sports Hall where they do their regular training. Informed consent forms regarding the purpose, safety and ethics of the research were also distributed to their parents, and all participants completed a statement of informed consent. The Medical Research Ethics Committee of Faculty of Medicine approved this study (protocol no: 2740-GOA).

First, the participants' height and weight were measured. This was followed by a 10-minute standardized (without static stretching) general warm-up protocol. After the warm-up, the participants took a vertical jump test and their flexibility measurements were taken. A two-minute standardized gymnastics series (Figure 4) that lasted 8 minutes in total was performed between the tests. The tests were taken immediately after the applied series. 2 minutes of active rest was given before the series were applied. A one-minute rest was given between the tests. The change in these effects was examined with the help of the tests applied while performing the series. The series was performed four times in total. Jump tests and flexibility measurements were performed between the series, and after the last one, the time course of changes of the results was evaluated. These two separate implementations showed whether the possible changes resulted from static stretching or fatigue. In order to prevent the samples to be affected by such factors as circadian rhythm, temperature, moisture etc., the tests were performed at the same times of the day. The total tests and series took approximately 65 minutes.

The tests used vertical jump heights (NewTest 2000; the Newtest Powertimer testing system was shown to be a useful instrument for measuring jump height and running speed); body fat percentages (skinfold) motion analysis software (Dart Fish); height (cm)-weight (kg) measurements; high definition camera (Go-pro) markers, and the sit and reach test. It was recorded at 240fps in 1:1 mode. Wide angle was not used. Following a ten-minute general warm-up, the vertical jump test and flexibility measurements were taken. All measurements were taken at 9.00 a.m.

Vertical jump performance was measured using a portable force platform (Newtest, Finland). Each subject performed two maximal counter-movement jumps with approximately two minutes' recovery in between. The best vertical jump results were recorded in centimeters (Bosco et al., 1995).

Sit and reach flexibility test: athletes stretched forward from the trunk (waist and hip) without bending the knees, with their hands in front of the body (Liemohn, Sharpe, & Wasserman, 1994) (figure 2). In order to get the most accurate result, there was a pause of two seconds without stretching forward or backward; the test was repeated twice, and the highest value was obtained. Also, approximately two minutes rest was given in between the tests.

As seen in Figure 3, the participants were asked to do the branch-specific straddle jump, As to the specific jumping test, their pictures taken with a high definition camera were evaluated on the Dartfish motion analysis software and the athletes' flexibility was estimated by looking at the angular change. The frame rate is 29 frames per second. Markers were placed on the athletes in order to make it easier to watch the pictures. Two of the markers were placed on the patella and the other two in the middle of the iliac bones, which made it possible to watch the straddle jump degree during exercise. Immediately after the baseline measurements, static stretching exercise was performed in four stations, each one lasting 30 seconds. This was followed by a two-minute standardized gymnastics series. The series were performed four times in total. Jump height and flexibility were measured after each series and the results were examined for time course of changes. In the study, four static stretching exercises were performed. These exercises are usually performed as gymnastics moves (Figure 4). Each stretching exercise lasted 30 seconds. The series included 12 most commonly performed gymnastics moves. The tests were performed in the same order after each series

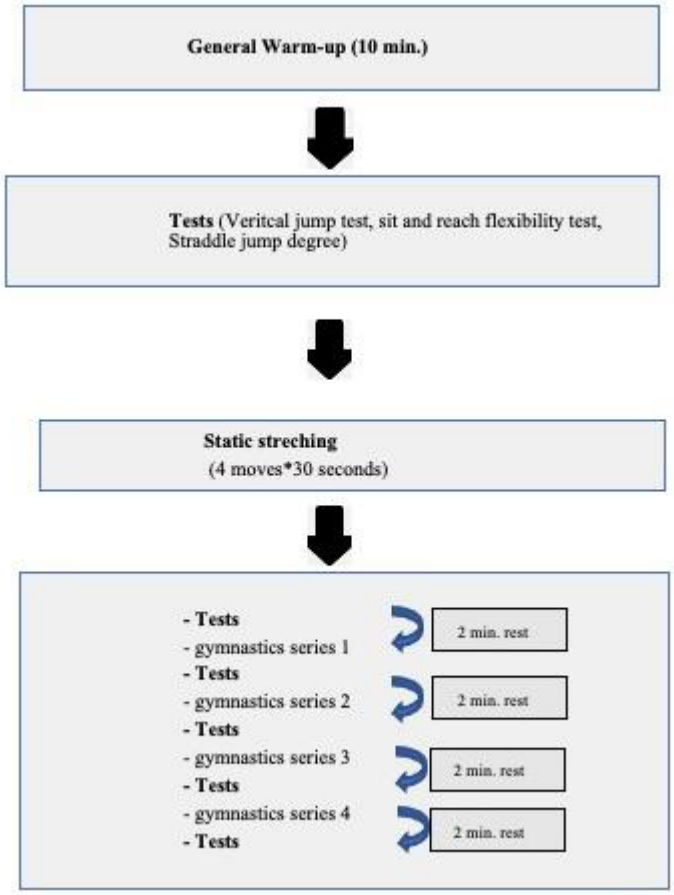

Figure 1. Schematic illustration of the experimental protocol instruments

Figure 2. Sit and reach test
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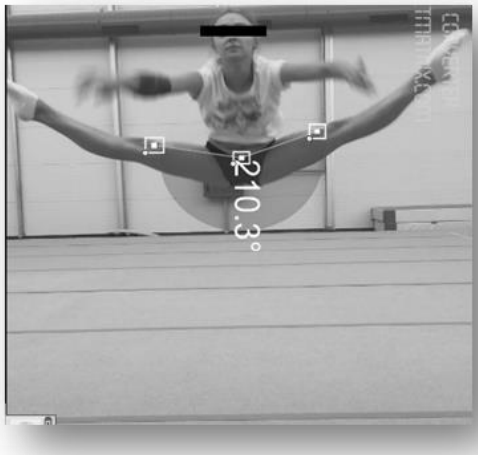

Figure 3. Angular evaluation in straddle movement with the Dartfish motion analysis software

For data analysis, descriptive statistics were calculated for the athletes' physical characteristics, jumping values (cm) and flexibility (cm) values. The Shapiro-Wilk test was performed to see whether the participants' descriptive statistics were normally distributed or not. The Shapiro-Wilk test results showed that the data distributed normally, and repeated measures ANOVA analysis was conducted with a Bonferroni correction. The tables show standard deviation, the lowest and the highest values, Δ difference (difference between mean values), statistical values and effect sizes.

The data analysis was conducted using SPSS 21.0 software. The effect size (ES) was calculated according to means and standard deviation. Cohen's d ESs were categorized as no effect (0-0.2), small effect (0.2-0.5), moderate effect (0.5-0.8) and large effect (0.8) Cohen, J. E. (1988). The level of significance was accepted as $p<0.05$.

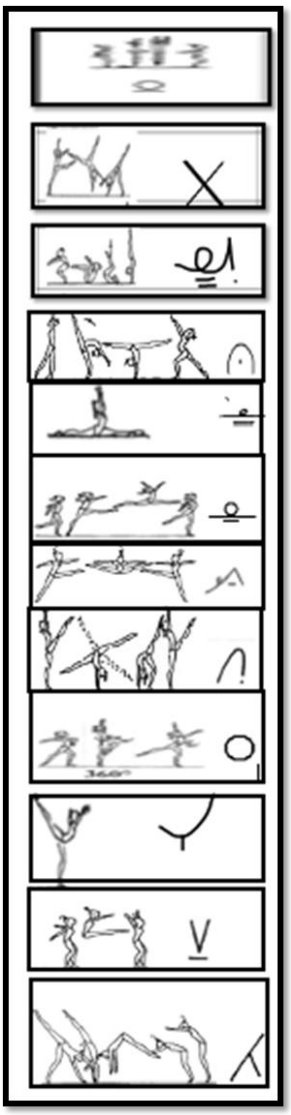

Figure 4. Gymnastics series consisting of 12 movements (FİG,2022)

RESULTS AND DISCUSSION

Participants' descriptive statistics are presented in Table 1.

As shown in Table 2, according to the ANOVA results, the values obtained were F (5.65) = 5.588, p= 0.00, np2 =0.301 in the jump test. Changes were examined between the vertical jump measurements after static stretching and repeated measurements. The test results showed a significant difference between $Jump_2$ (after static stretching) measurements and all repeated measurements. A significant difference (p=0,01) was seen between $Jump_1$ and $Jump_2$. A 2.42cm decrease was found in the vertical jump height between the baseline measurements and measurements after static stretching. Significant differences were found between $Jump_2$ and $Jump_3$ (p=0.03), $Jump_2$ and $Jump_4$ (p=0.01), $Jump_2$ and $Jump_5$ (p=0.004), and between $Jump_2$ and $Jump_6$ (p=0.009).

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Table 1
Participants characteristics N= 14 (Mean ± SD).

	Min.	Max.	X ± SD
Age	9.0	14.0	10.78 ± 1.80
Weight (kg)	23.0	48.4	32.25 ± 8.62
Height (cm)	122.6	159.0	136.7 5± 11.07
BMI (Kg/m^2)	14.6	21.3	16.95 ± 1.88
Sports experience (years)	4.0	10.0	6.14 ± 2.07
Body fat (%)	7.0	17.1	11.2 ± 3.16

X ± SD; Mean and Standard deviation.

Table 2
Changes between observations in vertical jump height (cm) after the static stretching protocol (N=14).

	X ± SD	Min.	Max.	Δ Difference	Bonferroni P	Effect Size
$Jump_1$	34.9 ± 2.6	31.0	41.0	-2.4	0.01	0.07
$Jump_2$	32 5 ± 3.6	24.0	38.0			
$Jump_2$	32 5 ± 3.6	24.0	38.0	+1.9	0.03	
$Jump_3$	34 4 ± 3.5	31.0	41.0			0.05
$Jump_2$	32.5 ± 3.6	24.0	38.0	+2.5	0.01	
$Jump_4$	35.0 ± 2.3	31.0	39.0			0.08
$Jump_2$	32.5 ± 3.6	24.0	38.0	+3.7	0.004	
$Jump_5$	36.2 ± 2.7	33.0	42.0			0.11
$Jump_2$	32.5 ± 3.6	24.0	38.0	+3.5	0.009	
$Jump_6$	36.0 ± 2.8	30.0	40.0			0.10

Jump; Jumping Performance, SS; Static stretching protocol, X ± SD; Mean and Standard deviation. *p<0.05.

As seen in Table 3, according to the ANOVA results, the values obtained were F (2.147, 27.908) = 2.443, p = 0.102, np2 = 0.158 in the reach test. No statistically significant difference was found between the baseline measurements ($reach_1$) and measurements after static stretching ($reach_2$) in the sit and reach flexibility test results. Significant differences were found in Reach3, Reach5 and Reach 6 between the measurements taken after static stretching and the repeated measurements ($reach_{2)}$

According to the ANOVA results, the values obtained were F (3.159, 41.07) = 2.45, p= 0.74, np2 =0.159 in the SJD test. In the straddle jump degree (SJD) measurements, no significant difference was found between the baseline measurements (SJD_1) and measurements after static stretching (SJD_2) and repeated measurements (SJD_3, SJD_4, SJD_5, SJD_6) (Table 4).

As seen in *Figure 3*, on the day of static stretching, vertical jump height measured after static stretching was found to be significantly lower than the baseline measurements. A decrease of 2.42cm can be seen between the baseline measurements (1) and the measurements taken after static stretching. Jump performance gradually improved in the repeated measurements

Table 4
Changes between SJD *Measurements after Static Stretching and Repeated Measurements (N=14.)*

	X ± SD	Min.	Max.	Δ Difference	P	Effect Size.
SJD° 1	198.1 ± 13.3	179.4	216.0	+0.9	0.550	0.08
SJD° 2	199.1± 11.1	183.3	216.6			
SJD °2	199.1± 11.1	183.3	216.6	+1.8	0.232	0.17
SJD 3	201.0± 11.0	184.3	217.0			
SJD °2	199.1± 11.1	183.3	216.6	+2.7	0.214	0.21
SJD °4	201.8 ± 14.0	180.0	218.9			
SJD° 2	199.1± 11.1	183.3	216,6	-3.5	0.258	0.27
SJD 5	195.5± 14.3	178.1	215.1			
SJD° 2	199.1± 11.1	183.3	216.6	-0.4	0.871	0.03
SJD° 6	198.6 ± 13.0	175.8	218.4			

SJD°; Straddle jump degree, X ± SD; Mean and Standard deviation. *p<0.05

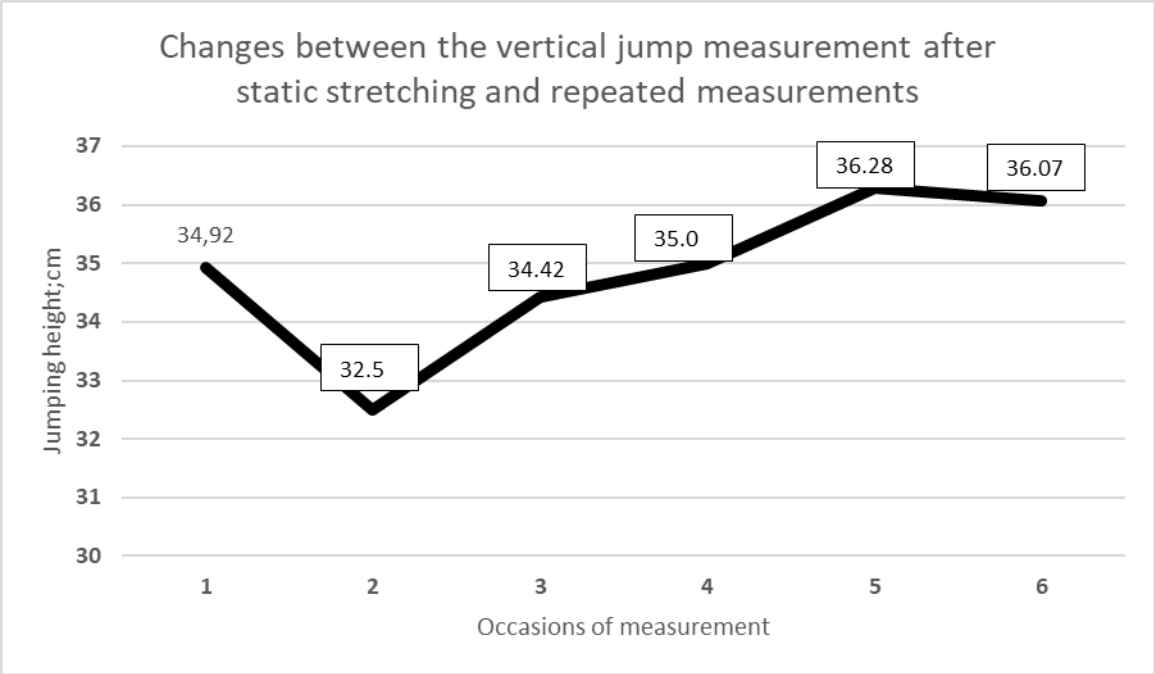

Figure 5. Changes between the vertical jump measurements after static stretching and repeated measurements (cm). 1 (Baseline measurement), 2 (Measurement after static stretching), 3 (Measurement after series 1), 4 (Measurement after series 2), 5 (Measurement after series 3), 6 (Measurement after series 4).

DISCUSSION

The aim of the present study was to examine the time course of changes of the effects of static stretching on artistic gymnastics-specific jump moves, vertical jump height and flexibility in artistic gymnasts. According to our findings, the static stretching protocol decreased vertical jump performance but had no effect on the artistic gymnastics- straddle jump move.

Many types of warm-up exercises are used in artistic gymnastics, so it is important to determine their effects on performance in planning training programs, decreasing injuries and optimizing performance (Robbins, & Scheuermann, 2008). Studies have reported many negative effects of static stretching on performance. Static stretching was found to decrease quadriceps and hamstring muscle strength significantly (Sekir et al., 2015). It is also reported that the intensity and duration of static stretching can change performance considerably and that high-intensity and long-duration static stretching exercise leads to losses in strength (Freitas et al., 2015). The negative effects of static stretching are considered to result from the decreased participation of motor units and the resulting decrease in the muscular tension and inhibition of the muscle (Knudson et al., 2011). Researchers associated the static stretching related decrease in performance with neural factors. For instance, when stretched beyond its resting length, the muscle reduces strength transfer to the skeletal system, which may lead to losses in performance (McHugh & Nesse, 2008).

Additionally, one of the causes of these strength losses is the reaction of the Golgi tendon organ to the stretched muscle (Avela et al., 1999). A significant difference was found between $Jump_1$ and $Jump_2$ in our study ($p=0,01$). In the New Test results, taken following a general warm-up, the athletes recorded an average vertical jump height of 34.92cm. A mean jumping performance was measured at 32.50 cm after static stretching, which indicated a decrease of approximately 2.50cm in jump

height. This finding supports many other studies reporting that static stretching negatively affects jump performance. The mean heights in the New Test of the 2-minute series 1, 2, 3 and 4 performed after static stretching were 34.42cm, 35.00cm, 36.28cm, and 36.07cm, respectively. Although the post-static stretching negative effect weakened after the first series, it could not reach the baseline value as a 0.5 cm difference was still found from the baseline measurement. However, it returned to the baseline value following the second series with an increase of 0.07 cm in jump height. Nevertheless, these differences are not significant statistically. The reason for all these could be the fact that as a result of the inverse myotatic reflex on the tendon stretched with the muscle tension, the tendon inhibits the muscle to which it is connected. Stretching exercises are generally performed to improve flexibility (Stone et al., 2006). Static stretching increases joint motion range (Laban, 1962). Unlike many other studies, no significant result was obtained showing that static stretching improves flexibility in the sit and reach flexibility tests in our study.

The fact that no significant difference was found in the flexibility measurements after static stretching may be because the participants are elite athletes with an advanced level of flexibility. The straddle jump is a move that is frequently used in gymnastics and has several variations. In our study, no significant difference was found in the SJD measurements of the athletes in the artistic gymnastics-specific jump move after static stretching. This could have resulted from the negative effect on their jump performance. Their vertical jump performance decreased on average by 2.42cm after static stretching. Since the athletes could not perform a good vertical jump, their SJD measurement results may not have differed significantly. Another reason could be the dynamic stretch reflex. The dynamic stretch reflex is activated by the strong dynamic impulse sent by the primary endpoints of the muscle fibers because of the rapid stretching of the muscle (Mukherjee & Chakravarty, 2010).

CONCLUSIONS

The static stretching protocol decreased vertical jump performance but had no effect on the artistic gymnastics-straddle jump move. In addition, static stretching was seen to have no acute effect on gymnasts' flexibility as a result of the sit and reach flexibility test. Therefore, if static stretching is performed before a competition, as it decreases jump performance, a two-minute static stretching protocol with each stretch held for 30 seconds may cause the athlete to experience a considerable deterioration in her jumping performance. It is recommended that protocols of different durations with different techniques for static stretching be conducted in future studies to examine the effects on the athletes' performance in further detail.

REFERENCES

Ament, W., & Verkerke, G. J. (2009). *Exercise and Fatigue. Sports Medicine,* 39(5), 389–422. https://doi.org/10.2165/00007256-200939050-00005

Amiri-Khorasani, M. (2013). Kinematics analysis: the acute effect of different stretching methods on dynamic range of motion of lower extremity joints during soccer instep kicking. *İnternational Journal Performance Analysis Sport*, *13*(1), 190-199.

Amiri-Khorasani, M., Sahebozamani, Mansour., Tabrizi, Kourosh G., & Yusof, Ashril, B. (2010). Acute effect of different stretching methods on illinois agility test in soccer players. *Journal of Strength and Conditioning Research*, *24*(10), 2698-2704.

Avela, J., Kyrolainen, H., & Komi, PV. (1999). Altered Reflex Sensitivity After Repeated and Prolonged Passive Muscle Stretching. *Journal Applied Physiology*, 86, 1283–91.

Behm, DG., Button, DC., & Butt, JC. (2001). Factors Affecting Force Loss with

prolonged stretching. *Journal Applied Physiology*. *26*(3), 262–72.

Behm, DG., & Chaouachi, A. (2011). A review of the acute effects of static and dynamic stretching on performance. *European Journal of Applied Physiology*, *111*(11), 2633–51.

Booth, L. (2008). Mobility, stretching and warm-up: Applications in sport and exercise. *SportEX Medicine*, 37, 20–23.

Bosco, C., Belli, A., Astrua, M., Tihanyi, J., Pozzo, R., Kellis, S., … Tranquilli, C. (1995). A dynamometer for evaluation of dynamic muscle work. *European Journal of Applied Physiology and Occupational Physiology*, 70(5), 379–386. https://doi.org/10.1007/BF00618487

Chaabene, H., Behm, D. G., Negra, Y., & Granacher, U. (2019). Acute Effects of Static Stretching on Muscle Strength and Power: An Attempt to Clarify Previous Caveats. *Frontiers in Physiology*, 10. https://doi.org/10.3389/fphys.2019.01468

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

Cross, KM., & Worell, TW. (1999). Effects of a Static Stretching Program on the Incidence of Lower Extremity Musculotendinous Strains. *Journal of Athletic Training*, *34*(1), 11–4.

Fletcher, I. BJ. (2004). The effect of different warm-up stretch protocols on 20 meter sprint performance in trained rugby union players. *Journal of Strength and Conditioning Research*, 18:885–888.

Fox, E.L., (1988). Bowers, R.W., Foss ML. The Physiological Basis of Physical Education and Athletics. Sounders College Publishing, 128.

Fédération Internationale De Gymnastique, Women's Artistic Gymnastics, 2022-2024 Code of Points.

Freitas, SR., Vilarinho, D., Vaz, JR., Bruno, PM, Costa, PB., & Mil-homens, P. (2015). Responses to static stretching are dependent on stretch intensity and duration. *Clinical Physiology and Functional Imaging*.*35*(6):478–84.

Hartig, D HD. (1999). Increasing Hamstring Flexibility Decreases Lower Extremity Overuse Injuries in Military Basic Trainees. *American Journal of Sports Medicine*, *27*(2):173–6.

Jeni, R., & Mcneal, WS. (2003) Acute static stretching reduces lower extremity power in trained children. *Pediatric Exercise Science*, 15:139–145.

Knudson, D., Bennett K., Corn, R., Leick, D., & Smith, C. (2011). Acute effects of stretching are not evident in the kinematics of the vertical jump. *Journal of Strength and Conditioning Research*, 15, 98–101.

Konrad, A., Reiner, M. M., Thaller, S., & Tilp, M. (2019). The time course of muscle-tendon properties and function responses of a five-minute static stretching exercise. European Journal of Sport Science, 19(9), 1195–1203. https://doi.org/10.1080/17461391.2019.1580319

Laban MM. (1962). İmplications of İts Response to Stress İn Vitro. *The Archives of Physical Medicine and Rehabilitation*, *43*(9):461–5.

Liemohn, W., Sharpe, G. L., & Wasserman, J. F. (1994). *Journal of Strength & Conditioning Research*,8:91-94.

Magnusson, S.P., (1998). Passive properties of human skeletal muscle during stretch manoeuvres. *The Scandinavian Journal of Medicine & Science in Sport*, 8:65–77.

McHugh, M. P., & Nesse, M. (2008). Effect of stretching on strength loss and pain after eccentric exercise. *Medicine and Science in Sports and Exercise*, 40(3), 566–573. https://doi.org/10.1249/MSS.0b013e31815d2f8c

Mukherjee, A., & Chakravarty, A. (2010). Spasticity mechanisms - for the clinician. Frontiers in Neurology, MAR(December), 1–10. https://doi.org/10.3389/fneur.2010.00149

Papia, K., Bogdanis, G. C., Toubekis, A., Donti, A., & Donti, O. (2018). Acute effects of prolonged static stretching on jumping performance and range of motion in young female gymnasts. *Science of Gymnastics Journal*, *10*(2), 217–226.

Power, K., Behm, D., Cahill, F., & Carroll, M YW. (2004). An acute bout of static stretching: effects on force and jumping performance. *Medicine and Science in Sports and Exercise*, *36*(8):1389–96.

Robbins, JW., & Scheuermann, BW. (2008). Varying amounts of acute static stretching and its effect on vertical jump performance. *Journal of Strength and Conditioning Research*, *22*(3):781-6.

Sekir, U., Arabaci R., & Akova B. (2015). Acute effects of static stretching on peak and end-range hamstring-to-quadriceps functional

ratios. *World Journal of Orthopedics*, *6*(9):719–26

Shellock, FG PW. (1985). Warming-up and stretching for improved physical performance and prevention of sports-related injuries. *Sports Medicine*, *2*(4):267–78.

Shrier, I. (2004). Does Stretching İmprove Performance? A Systematic and Critical Review Of The Literature. *Clinical Journal of Sport Medicine*, Sep;*14*(5):267-73

Stone, MH., Ramsey, MW., Kinser AM., Bryant HS., & Ayres C SW. (2006). Stretching: acute and chronic? The potential consequences. *Journal of Strength and Conditioning Research*, 28:66–74.

Young, W. SE. (2001). Acute effects of static stretching, proprioceptive neuromuscular facilitation stretching, and maximum voluntary contractions on explosive force production and jumping performance. *Research Quarterly for Exercise and Sport*, 72:273–27

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Article received: 28.9.2022
Article accepted: 24.1.2023

EFFICACY OF BALANCE TRAINING TO IMPROVE BALANCE OF YOUNG FEMALE GYMNASTS

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Original article *DOI:15.1.87 - 96*

Abstract

Gymnastics is a popular sport that has potential strength, flexibility, and personal growth benefits for athletes. Both static and dynamic balance are developed from a young age and are fundamental to higher-level gymnastics. PURPOSE: To assess the efficacy of a balance training protocol in improving the dynamic balance of young female gymnasts. METHOD: 19 female Junior Olympic (JO) Level 3 gymnasts, ages 6-11, were randomly assigned to the Balance Training (BT) or control groups. The BT group completed a variety of balance exercises during each practice (2x/wk for eight weeks), including one-footed balance, hopping skills, and leaps onto surfaces of varying stability. Gymnasts in the control group continued with their normal gymnastics practices. Gymnasts were tested before training, after week 4, and after week 8 to assess improvements in the Balance Error Scoring System (BESS), Star Excursion Balance Test (SEBT), Center of Pressure Path length (COP Path length), and Joint Position Sense (JPS) scores. RESULTS: An improvement in SEBT for the gymnasts' dominant foot reaching anteriorly (p=0.03) was observed. Otherwise, there were no significant differences between improvements in scores for the control group and the experimental group. CONCLUSION: JO Level 3 gymnasts, who are early in their training and development, demonstrated no additional benefit from twice weekly balance training beyond normally prescribed practice and skills training. While anecdotal evidence suggested a possible acute effect on balance performance immediately following balance exercises, further research is needed.

Keywords: *proprioception, USAG Junior Olympic gymnastics, balance, vestibular*

INTRODUCTION

Women's gymnastics is a sport that is primarily performed by young female athletes, and has featured in the Olympics for decades (Sands, 1999). Among the many benefits of participation in this sport are those that come from adaptations that occur due to the sport's anaerobic, strength, and flexibility challenges (Sands, 1999). Gymnasts require incredible dynamic balance and proprioceptive abilities to perform skills on all four competitive events. Along with visual and vestibular input, proprioceptive input helps maintain balance (Claxton et al., 2006) by providing precision in both the conscious and unconscious control of moving limbs (Holm et al., 2004). While the training of gymnastics skills may be expected to improve balance and proprioception over time, there is currently no evidence

indicating whether targeted training can further develop these abilities in young female gymnasts.

Dynamic balance is described as the ability to maintain postural control or equilibrium by controlling the body's center of gravity within its base of support during any skills in which motion of one's center of gravity occurs due to muscular activity (Claxton et al., 2006; DiStefano et al., 2009, 2009; Kinzey & Armstrong, 1998). As a contributor to dynamic balance, proprioception can be explained as the knowledge of the location of one's body in space. More specifically, proprioception is the combination of discreet kinematic input from sensory receptors in the muscle, skin, and joints, and from central signals arising from motor output (Taylor, 2009). These factors are particularly pertinent to skills performed on the balance beam and floor exercises, as well as landings from aerial skills and dismounts from each event.

It was not until recent decades that balance training was recognized as a tool that would be beneficial for healthy young athletes, due to its potential to reduce risk of injury and contribute positively to athletic performance (Claxton et al., 2006). Neuromuscular training regimens, which may include protocols that challenge the young female athletes' strength, agility, or balance, have been shown to improve balance and proprioception in non-gymnasts (Filipa et al., 2010; Holm et al., 2004). There is limited balance and proprioception research including female subjects under the age of 18. Therefore, evidence-based approaches to improve and measure dynamic balance and proprioception in gymnasts are relatively scarce. It is of interest to investigate a potential training protocol to achieve such effects.

Thus, the aim of this study was to implement and assess a balance training protocol for its efficacy in improving dynamic balance and proprioception of young female gymnasts using both standardized laboratory and modified gymnastics specific tests. More specifically, we focused on young female gymnasts training at an early competitive level (USAG Level 3). It was hypothesized that this training intervention would result in greater balance and proprioception improvements than those achieved by a control group of gymnasts continuing with conventional gymnastics practices only..

METHODS

19 female subjects, ages 6-11, participated in this study. Subjects averaged a height of 131.45+/-8.46 cm and had the skills to compete as United States of America Gymnastics (USAG) Junior Olympic (JO) Level 3 gymnasts. This was the first JO Level of competitive gymnastics for all gymnasts participating in the study. Attendance was recorded to ensure compliance. Gymnasts attended 88% of the training sessions on average, including at least one during every week of training. Gymnasts who were physically unable to perform strenuous physical activity causing them to refrain from any part of their typical gymnastics practice were excluded from the training intervention. All gymnasts were part of the same team and practiced together twice per week for a total of eight hours. To control for developmental differences, gymnasts were matched by age and gymnastics experience, then pairs were randomized into either the control or the experimental group.

Training intervention took place twice per week for eight weeks and was integrated into their regular gymnastics practices. The training stimulus consisted of agility dot exercises, a one-footed static balance task, and a dynamic one-footed landing task. The difficulty of the exercises increased at the end of week 2 and again at the end of week 5. Balance and proprioception were assessed at the beginning, middle, and end of the eight weeks. Testing was performed in a laboratory setting and consisted of four assessments: Center of Pressure Path length (COP Path length) following a landing from

a split leap, the Balance Error Scoring System (BESS) test, the Star Excursion Balance Test (SEBT), and the Joint Position Sense (JPS) test. Assessments aimed to identify improvements in gymnastics-specific performance outcomes as well static balance, dynamic balance, and proprioception, respectively. Technicians and raters were blinded to the gymnasts' groups and followed scripts to ensure unbiased testing.

The agility dot drill was included as an exercise intended to stress dynamic balance, leap/landing dynamics, and proprioception, specifically, of the foot and ankle. The exercise was incorporated into the experimental group's warm-up. All 19 gymnasts began their practice with running and stretching. The ten gymnasts receiving balance training then performed six repetitions of each of the day's three prescribed dot patterns. Agility dot hopping patterns were done on five dots in the shape of an X (Figure 1) and included both one-footed and two-footed challenges of increasing difficulty as training progressed. The control group proceeded with a normal team warm-up, which did not include specific balance training interventions

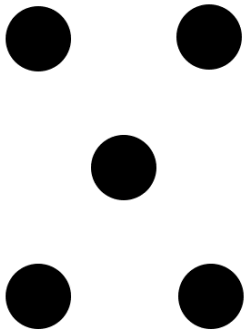

Figure 1. Layout for the dot drill. Outer dots were spaced at 24in x 36in (54cm x 91cm)

The stationary balance exercise was completed during the gymnasts' daily rotation on the balance beam. Gymnasts stood on one foot for 10 seconds, repeating this for each foot three times. The difficulty of the exercises increased in such a way that the first phase was performed on a foam balance pad (Airex, Switzerland); moved at the end of week 2 to a less stable surface, a BOSU ball (BOSU, USA), and then again, after week 5, to the least stable surface, a Dyna Disc (Exertools, USA). Between established progressions, gymnasts were individually monitored as they transitioned to more challenging versions of the one-footed static balance task; an additional challenge was moving their arms from abducted with extended elbows to placing hands on hips, and further performing the task with their eyes closed.

The dynamic landing exercise was also completed during the gymnasts' daily rotation on the balance beam. The ten leaps were divided in half: five on each foot were performed both before and after the static balance exercise. Gymnasts performed split leaps, landed on one foot inside an area of the floor that had a taped rectangle approximately 40cm x 60 cm. They were instructed to stick and hold their landing for three seconds. In the first phase gymnasts landed the leap on flat ground, which was transitioned at the end of week 2 to a foam balance pad, and then again after week 5 to a BOSU ball.

Testing took place in a laboratory setting. Testing sessions began with a

prescribed warm-up that included three practice leaps on each leg and six reaches per foot in each of the three SEBT reaching directions. Gymnasts were randomly divided to start at one of four stations. Upon completing their first station, gymnasts would transition independently through the other three tests.

Gymnasts performed a one-footed landing on a force plate (Bertec, USA) following a split leap with a two-step lead-in. This sport-specific skill simulates the leap skill performed in the JO Level 3 balance beam routine. Three leaps were performed on each foot and gymnasts were instructed to hold their landing for at least three seconds. The order of self-identified dominant (D) or non-dominant (ND) foot was randomized. COP path length has been utilized in past studies with the force plate being commonly recognized as a gold standard for measuring acute differences in balance abilities (Sabchuk et al., 2012). Gymnasts' COP Path length was measured for a minimum of three seconds; trials in which gymnasts were hopping upon landing or the landing was not held for three seconds were discarded then repeated.

The BESS is a reliable and valid static balance test (Hansen et al., 2017) that consists of three skills: a two-footed stance, a one-footed stance on the non-dominant foot, and a tandem stance with dominant foot in front on a foam balance pad (Airex, Switzerland). All skills required gymnasts to have their eyes closed and their hands on the hips. Two trained, unbiased raters scored gymnasts and total errors were calculated and averaged between the two raters. An overall higher score indicates poorer performance. The traditional BESS test involves performing each of the stances both on the floor and on the Balance Pad, but the floor portion was eliminated for this study due to its relative ease in this population; it was not expected to be able to assist in the discernment between two high performers (DiStefano et al., 2009). A summative total score was calculated as a total error of each of the three positions.

The SEBT is a reliable and valid tool used to assess dynamic balance abilities (Ricotti, 2011). For this study, each subject's ability to extend their non-supporting leg was measured in three directions: anterior, posterolateral, and posteromedial. Distances were measured using tape with inch gradations. Gymnasts performed three reaches in each direction, standing with the big toe of their supporting foot on the center. The order in which the reaches were performed was randomly selected, as was the foot with which gymnasts reached first.

JPS can be defined as a person's ability to actively or passively reproduce a predetermined joint angle, and has emerged as a reliable and valid mechanism for quantifying proprioceptive abilities (Elshemy & Battecha, 2013). The protocol for this assessment was modified from a JPS test used previously (Ettinger et al., 2017). Joint position was determined using a custom LabVIEW program (National Instruments, USA) using accelerometry data from an iPod (Apple, USA). Changes in the angle of hip extension were measured as the gymnasts were cued to perform arabesque repetitions. An arabesque is a standard position that Level 3 gymnasts must hold on the balance beam, and the angle of hip extension in an arabesque was used for this study. Prior to testing, subjects were familiarized with the protocol and performed several practice trials until comfortable with the equipment and the environment. Eyes were closed to eliminate visual input as a proprioceptive aid for this test.

To initiate the assessment, the application audibly cued extension of the hip into an arabesque with a low constant tone. Real-time feedback of their position was provided with the tone remaining low or changing to high, corresponding to the need to raise and lower their leg, respectively. Subjects, as prompted before testing, knew to memorize the "target" position, which was held for two seconds and pre-set to be either 30˚, 45˚, or 60˚ with

allowance for plus or minus 10˚. The command "relax" told subjects to return to the standard anatomical position for two seconds, and was followed three seconds later by a cue to "find target". In silence, subjects repositioned their leg in an arabesque which they felt most closely resembled the one they had completed seconds before. Once still for two seconds, the command "relax" would play again, indicating the end of that trial. Nine trials (three for each target angle range) were completed in a randomized order. Average error was calculated for each joint angle.

Statistical analyses were conducted using SYSTAT 13. Data were tested for assumptions of normality and homogeneity of variance. The independent variable was assessed as the completion of either the balance and proprioception intervention or the control. The dependent variables included the COP path length, SEBT score, BESS score, and JPS score as described above. The difference in training outcomes for each dependent variable between groups was analyzed using a within-subjects mixed ANOVA analysis. Additional post-hoc pair-wise comparisons were run to analyze stage-by-stage differences. Statistical significance was set at $\alpha = 0.05$. Values are presented as mean ± SD.

This study received approval from the Institutional Review Board. Prior to participation, both Child Assent and Parental Consent were obtained.

RESULTS

The COP test did not identify any statistically different changes in the performance of the experimental group when compared to those of the control group. Individual changes of the experimental group's dominant foot path lengths measured for one second following their landing can be seen in Figure 2. The experimental group saw a general decrease in COP across the three timepoints, averaging 0.197±0.07 cm, 0.182±0.04 cm, and 0.165±0.05 cm for the pre, mid, and post sessions, respectively. The change in the control group's COP values varied more across timepoints, averaging 0.199±0.08 cm, 0.210±0.04 cm, and 0.165±.034 cm for the pre, mid, and post sessions, respectively. There was no significant difference between the groups (p=0.676).

This test did not identify any statistically different changes in the performance of the experimental group when compared to those of the control group. For the pre, mid, and post assessment sessions, the experimental group averaged scores of 11.25±2.46 errors, 10.85±3.25 errors, and 10.06±2.83 errors, while the control group scores were 12.83±2.65 error, 11.06±3.43 errors, and 11.56±3.61 errors across the three timepoints respectively (Figure 3).

Gymnasts of the experimental group reaching anteriorly with their dominant foot improved significantly more between the testing session at the end of week 4 and the end of week 8 than those in the control group (p=0.03). On average, the experimental group's scores improved from 59.3±7.7 to 60.5±8.1 cm (23.33±2.9 to 23.8±3.2 in) while the control group's reaching distances decreased from 61.9±6.4 to 58.2±5.1 cm (24.38±2.5 to 22.91±2.0 in) (Figure 4). No other statistically significant improvements were made in reaching distances when comparing the groups.

JPS did not identify any statistically different changes in the performance of the experimental group at the 30˚, 45˚, or 60˚ angles across the three timepoints when compared to those of the control group when performing the static arabesque skill (p>0.05 for all). The 45˚ target angle had a non-significant trend of improvement for the experimental group (p=0.059) (Figure 5); however, this was not different from the control group (p>0.05).

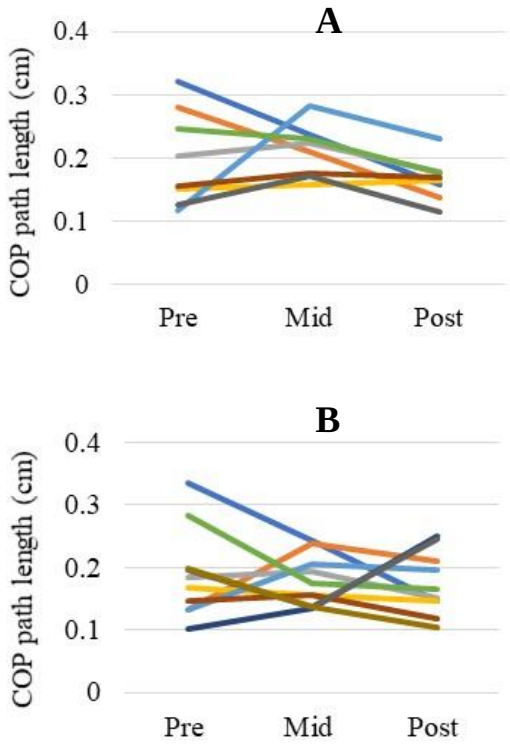

Figure 2. Changes in average COP scores for the experimental (A) and Control (B) groups

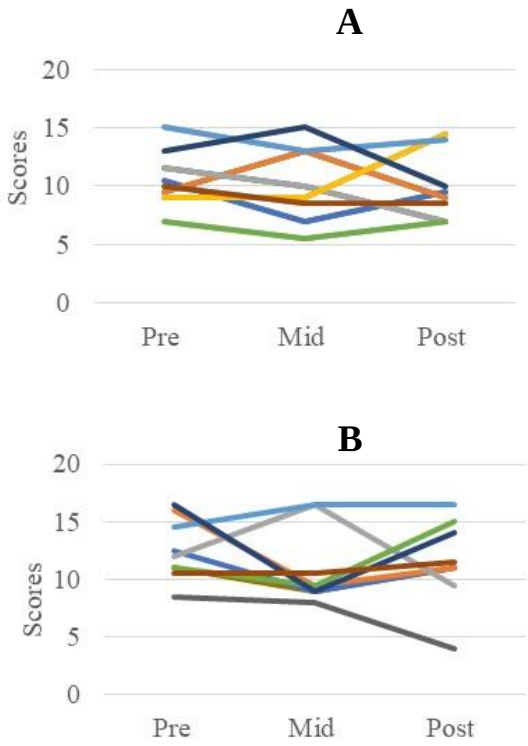

Figure 3. Changes in average BESS scores for the Experimental (A) and Control (B) groups. One subject in the experimental group did not complete her post-training assessment for the BESS test, her data was excluded from the graph, but was used to calculate average scores for the week zero and week four testing sessions.

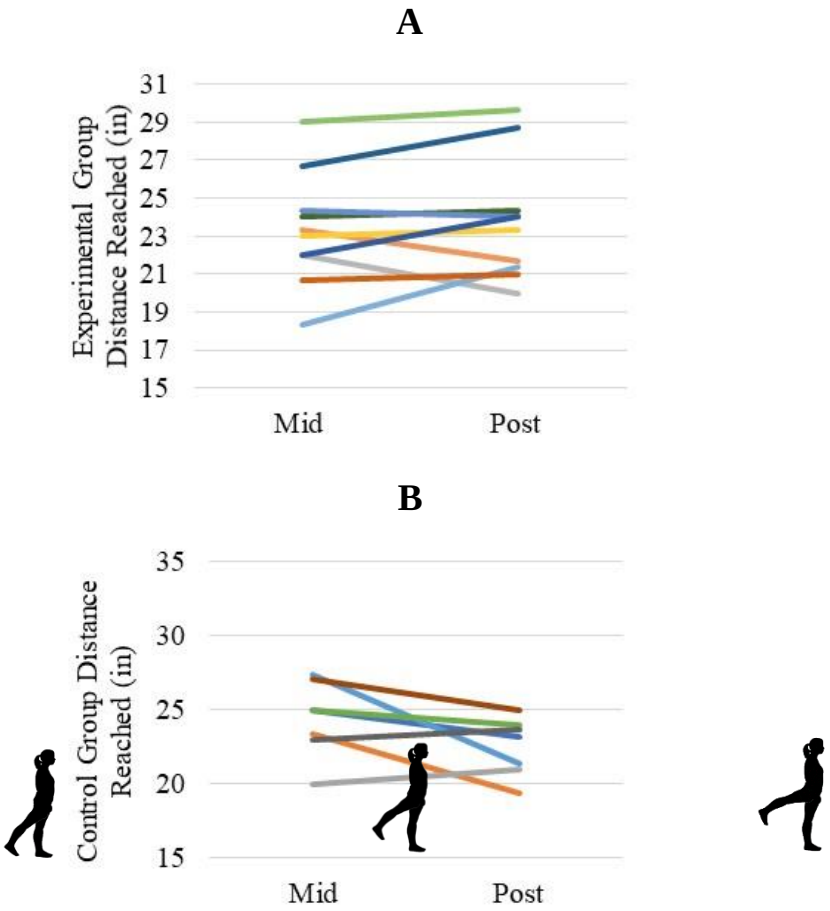

Figure 4. Changes in average dominant anterior SEBT reaching distances for the experimental (A) and Control (B) groups

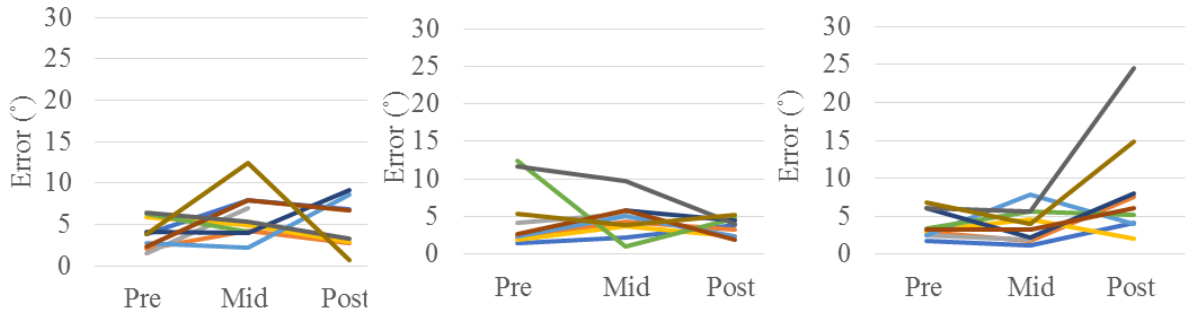

Figure 5. Changes in average JPS constant errors for the experimental group aiming for 30˚ (left), 45˚ (middle), and 60˚ (right).

DISCUSSION

The purpose of this study was to implement and assess the efficacy of a balance training protocol for pre-adolescent JO female gymnasts. Gymnasts who are early in their competitive training, JO Level 3, have the greatest potential for improvement in both their skills and their balance. The training stimuli were designed to improve performance on a sport-specific skill, as well as assessments of dynamic balance, static balance, and proprioception. For the SEBT, in the anterior direction when reaching with the dominant foot, the experimental group improved their scores significantly more than the control group between the assessment at the end of week 4 and at the end of week 8. However, all other assessments did not reveal any statistically significant differences between the groups. While trends towards improvement were apparent, they were not statistically different between the groups.

Despite support in the literature for the theoretical implementation of balance training with lower level (compulsory) gymnasts (Cohen et al., 2002), to our knowledge, this is the first study to investigate a balance or proprioception training intervention in young female gymnasts, particularly at a novice competitive level such as JO Level 3. When comparing to non-elite young females training in other sports we see that Filipa, et al. (2010) saw an improvement in SEBT with an 8-week neuromuscular training program which included core muscle training and balance stimuli twice per week in high-school competitive soccer players. Similarly, Valovich, et al. found an improvement in BESS and SEBT scores among female high school basketball players after a 6-week training intervention twice per week, including balance training. Holm, et al. (2004), similarly found improvements in balance and proprioception after a 5 to 7-week intervention, three days per week. However, this study utilized elite-level handball players. As compared to the present study, each of these studies implemented similar balance interventions across an equivalent duration of training. The focus of these studies was on older and more highly trained ball-sport athletes. These athletes were at a higher level of physical and sports-specific development than the younger and more novice gymnast in the present study. This difference in age and development may have affected the difference in results, specifically BESS and SEBT.

JO Level 3 gymnasts were chosen for this study because Level 3 is often the first level of competition, and therefore competitive training. Among the competitive levels, these gymnasts have the greatest potential for improvement and were, therefore, the focus of this study. Ultimately, this sample selection may have confounded the results. We believe that our balance training stimulus was not a sufficient overload beyond overload stimulus presented by standard practice in this early stage of training. Gymnastics training alone has been found to improve balance in young (4-6 years) children with no previous training (Akın, 2013). In the present study, for example: the COP path length outcome measure represented a sport-specific skill that could be improved through the training stimuli implemented. However, a split leap is a common focus of training at this level, so all subjects (both control and experimental) had ample practice in this skill throughout the study duration. The BESS test and SEBT are reliable and valid assessments that quantify improvements in static and dynamic balance, respectively. Drills on the balance beam involved a combination of static and dynamic balance, and gymnasts had about 45 minutes of training on the balance beam in each practice. Therefore, the training of the gymnasts could have specifically confounded these three outcome measures.

This study had a minimum of 50% attendance for inclusion in the final analysis; actual attendance exceeded 88%

of all sessions with at least one session per week. This requirement was based on past research utilizing only one training session per week for a period of 8 weeks or less (Heitkamp et al., 2001). Given that the gymnasts at this level only practice two days per week, and the gymnasts were just beginning competitive level training in JO Level 3, the balance training stimulus may have been insufficient to differentiate between the groups. Future research using similar balance training protocols could be conducted with subjects at higher JO levels, ensuring a distinctly different balance stimulus from their standard training.

A potential confounder to our results may be the orderly implementation of our multiple tests. As described above, at each testing timepoint athletes completed all tests in a randomized order, progressing immediately from one test to the next. Anecdotally, we observed that there may be an acute balance stimulus effect, which may confound the longitudinal measurements. The design of the dynamic and static balance portion of the training regimen allowed a comparison of the leap landing before and after the static balance training. While this study was not designed to observe acute effects, it was observed by coaches and researchers that the gymnasts performed subjectively better on their leaps following the static training when compared to their leaps performed prior to the static challenge. Similarly, coaches reported improved performance during balance beam practice immediately after gymnasts returned from balance training. These are biased and subjective reports, so future research should investigate an acute training effect. Currently, we are unaware of evidence in the literature that has specifically investigated the effects of an acute balance stimulus in athletes. In healthy young adults, however, a dynamic warm-up has been shown to improve SEBT scores as compared to a more static warm-up (Erkut et al., 2017). Should some acute effect exist, this may be a confounding factor in measuring longitudinal balance training effects. Establishing the existence of an acute effect would be interesting to consider as a pre-competition exercise for gymnasts, and therefore of interest in future research.

CONCLUSIONS

The selected balance training protocol was generally not a sufficient mechanism for improving young female gymnasts' balance beyond their performance gains acquired through regular JO Level 3 gymnastics practices. Additional research should be conducted on more well-trained gymnasts in an attempt to improve their balance, and the potential acute effect should be investigated.

REFERENCES

Akın, M. (2013). Effect of gymnastics training on dynamic balance abilities in 4-6 years of age children. *International Journal of Academic Research, 5*(2A), 142–146.

Claxton, D. B., Troy, M., & Dupree, S. (2006). A question of balance. *Journal of Physical Education, Recreation & Dance (JOPERD), 77*(3), 32–37.

Cohen, S. B., Whiting, W. C., & McLaine, A. J. (2002). Implementation of balance training in a gymnast's conditioning program. *Strength & Conditioning Journal*, *24*(2), 60–67.

DiStefano, L. J., Clark, M. A., & Padua, D. A. (2009). Evidence supporting balance training in healthy individuals: A systemic review. *Journal of Strength and Conditioning Research*, *23*(9), 2718–2731. https://doi.org/10.1519/JSC.0b013e3181c1f7c5

Elshemy, S., & Battecha, K. (2013). Kinesio taping versus proprioceptive training on dynamic position sense of the ankle and eversion to inversion strength ratios in children with functional ankle instability. *Med J Cairo Univ*, *81*, 61–68.

Erkut, O., Gelen, E., & Sunar, C. (2017). Acute effects of different warm-up

methods on dynamic balance. *International Journal of Sports Science*, *7*(3), 99–104.

Ettinger, L. R., Shapiro, M., & Karduna, A. (2017). Subacromial anesthetics increase proprioceptive deficit in the shoulder and elbow in patients with subacromial impingement syndrome. *Clinical Medicine Insights. Arthritis and Musculoskeletal Disorders*, *10*. https://doi.org/10.1177/1179544117713196

Filipa, A., Byrnes, R., Paterno, M. V., Myer, G. D., & Hewett, T. E. (2010). Neuromuscular training improves performance on the star excursion balance test in young female athletes. *The Journal of Orthopaedic and Sports Physical Therapy*, *40*(9), 551–558. https://doi.org/10.2519/jospt.2010.3325

Hansen, C., Cushman, D., Chen, W., Bounsanga, J., & Hung, M. (2017). Reliability testing of the balance error scoring system in children between the ages of 5 and 14. *Clinical Journal of Sport Medicine: Official Journal of the Canadian Academy of Sport Medicine*, *27*(1), 64–68. https://doi.org/10.1097/JSM.0000000000000293

Heitkamp, H. C., Horstmann, T., Mayer, F., Weller, J., & Dickhuth, H. H. (2001). Gain in strength and muscular balance after balance training. *International Journal of Sports Medicine*, *22*(4), 285–290. https://doi.org/10.1055/s-2001-13819

Holm, I., Fosdahl, M. A., Friis, A., Risberg, M. A., Myklebust, G., & Steen, H. (2004). Effect of neuromuscular training on proprioception, balance, muscle strength, and lower limb function in female team handball players. *Clinical Journal of Sport Medicine: Official Journal of the Canadian Academy of Sport Medicine*, *14*(2), 88–94.

Kinzey, S., & Armstrong, C. (1998). The reliability of the star-excursion test in assessing dynamic balance. *Journal of Orthopaedic & Sports Physical Therapy*, *27*(5), 356–360. https://doi.org/10.2519/jospt.1998.27.5.356

Ricotti, L. (2011). Static and dynamic balance in young athletes. *Journal of Human Sport and Exercise*, *6*(4). http://www.redalyc.org/resumen.oa?id=301023452005

Sabchuk, R. A. C., Bento, P. C. B., & Rodacki, A. L. F. (2012). Comparison between field balance tests and force platform. *Revista Brasileira de Medicina Do Esporte*, *18*(6), 404–408. https://doi.org/10.1590/S1517-86922012000600012

Sands, W. A. (1999). *Why Gymnastics?* USA Gymnastics Online: Technique. https://usagym.org/pages/home/publications/technique/1999/3/whygymnastics.pdf

Taylor, J. L. (2009). Proprioception. In L. R. Squire (Ed.), *Encyclopedia of Neuroscience* (pp. 1143–1149). Academic Press. https://doi.org/10.1016/B978-008045046-9.01907-0

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Article received: 17.6.2022
Article accepted: 7.1.2023

ANALYSIS OF HAND-FOOT/LEG PREFERENCES AND LATERALITY IN MOVEMENT DIFFICULTIES OF INDIVIDUAL ELITE RHYTHMIC GYMNASTS

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Original article *DOI:15.1.97-108*

Abstract

The aim of this study is to determine the number and ratio of hand-foot/leg preferences in movement difficulties used by individual elite senior rhythmic gymnasts in their routines. In the World Cup Competitions and European Championships held in 2021, the final competition routines (N=75) of gymnasts (N=28) were examined, and body and apparatus difficulties, and the number and rate of use of the preferred side were determined. Since gymnasts participated in more than one competition, their most recent competition routines were included in the research. The data were obtained by analyzing the routines recorded during the competitions. Explanatory statistical analyses of the data were conducted by using the IBM SPSS 25.0 statistical program. In all routines, while higher rates of between 56.2% and 87% were found in the right hand when compared to the left hand in throwing and catching, higher rates were found in the hoop and ribbon apparatus in throwing with the left foot when compared to the right foot. In the right foot/leg catches, the highest rates were observed in the hoop apparatus (49.6%). Left foot usage preferences were observed at rates varying between 65.1% and 97.4% in jumps/leaps difficulties and between 58% and 71% in balance difficulties. In rotation difficulties, the use of the right foot had higher rates of between 72.6% and 80% when compared to the left foot. Gymnasts showed a tendency to use the right hand predominantly in throws and catches, the left foot in jumps/leaps and balances, and the right foot in rotations.

Keywords: *Rhythmic gymnastics, individual routines, body and apparatus difficulties, hand-foot/leg preferences, video analysis.*

INTRODUCTION

Motor laterality or hand preference results from a natural asymmetry in the functional organization of the left and right hemispheres (Sainburg, 2016). Hand preference is generally inherited and affected by genetic, hormonal, developmental and cultural factors (Musalek, 2015; Faurie et al. 2016). Left-handed dominance makes up approximately 10-12% of the general population (Gilbert, & Wysocki, 1992), while 90% of them preferentially use their right hand (Peters et al. 2006). In studies, left brain dominance is often related to complex motor activities such as movements and tool use (Cochet, & Byrne, 2013; Faurie, & Raymond, 2004). Additionally, footedness is smilarly described as the leg used to manipulate an

object or bring forward in action (Peters, 1988).

Laterality in sports is related to the issues, such as coaching, skill, acquisition, performance, athlete development, motor control and understanding of perceptual-cognitive processes, talent identification, rehabilitation and injury prevention. Athletes determine their laterality by choosing their hands, feet, eyes, direction of rotation, support leg and jumping leg while performing their movements (Loffing et al. 2016). The relationship between hand/foot tapping performance (Kalaycıoğlu et al. 2008; Peters, 1988; Ziyagil, 2011), and the relationships between hand preference and rotational preference (Heinen et al. 2016) have been examined while taking into consideration the synergy between the support and functions of the extremities. In complex motor skill performances, lateral profiles of athletes have also been studied (Castañer et al. 2018).

Rhythmic gymnastics (RG), a sport practiced with aesthetic and technical movements (body and apparatus) accompanied by music, requires high-level motor control. It includes major goals, such as training, creating reserves in body movements and apparatus skills, increasing artistic effect, increasing dance and music motor skill reserve, maintaining flexibility, coordination, speed, strength and endurance skills at a desired level and improving the individual style and perfecting the presentation, improving compositions and achieving high results in competitions (Jastrjembskaia, & Titov, 1999). To increase the technical perfection of the movements and ensure their harmony with the music, many repetitions are necessary during training. However, these repetitions should be performed carefully. If exercises that support the development of the non-dominant side are not included, unilateral loads can cause cumulative musculoskeletal problems.

In a study (including a physician), the highest regional distribution rates (%) of RG injuries were reported: 23.9 in the back, 17.3 the knee, 15.2 the leg (tibia), 15.2 fthe oot, and 10.9 the ankle (Hutchinson, 1999). Muscle-tendon unit injuries were reported in 85% of gymnasts (Zetaruk et al., 2006). It has been stated that muscle-tendon unit imbalances are among the risk factors for stress fractures (O'Neill, & Micheli, 1988). In RG, movement patterns are performed against the laws of physics (gravity force, momentum force, etc.) and gymnasts' physical fitness abilities must be at the optimum level in order to perform their movements (involving the use of different axes, planes and levels) at a high technical level.

There are studies that show that asymmetry can be caused by excessive repetitions to ensure perfection in movements. In one study, lower extremity functional flexibility asymmetry was observed in gymnasts (Batista Santos et al. 2015). In addition, in a study examining the effect of lower extremity lateral preference on anthropometrics, the size of movement and isokinetic strength measurements in gymnasts, the observed differences were related to lateral preference and training (Frutuoso et al. 2016).

Motor preference tasks show an individual's tendency for laterality, but do not bring out the degree of lateralization in certain environments like sports (Utesch et al., 2016). Although there are limited resources, the determination of laterality, the rate and limits of laterality according to the apparatus, and the precautions to be taken have been specified. The degree of asymmetry also determines the methods of teaching an element, and if the asymmetry of an element of a young gymnast increases by 10%, it is recommended that the non-dominant arm/leg should perform this element 8-10 times. As the difficulty of the elements increases, the rate of asymmetry may be higher (17-54%), while this rate is lower (12-17%) in simple difficulties (Jastrejevskaya, 1995). The asymmetry of

acquired elements can be determined by the coach according to the evaluation rules.

Performance tasks, preference tasks, and questionnaires have been used as tools for evaluating laterality. Performance tasks have been used to evaluate the outcome and quality of left- and right-sided tasks, preference tasks have been used to elicit motor responses as an indicator of laterality, and questionnaires have been used to examine preferences in motor activities (Utesch et al. 2016; Oldfield, 1971; Elias et al. 1998; Prieur et al. 2017; İpek et al. 2021).

When compared to evaluations through questionnaires, observing the quality of performances to obtain additional objective information about the person's laterality may be valuable (Elliott, & Roy, 1996). This study was conducted in order to analyze the hand and foot/leg preferences of individual elite senior rhythmic gymnasts in the final competition routines, in apparatus and body difficulties.

METHODS

The final competition routines (N=75) in the apparatus (18 routines in the hoop, 17 in the ball, 21 in the clubs and 19 in the ribbon) of individual senior elite gymnasts (N=28) in the World Cup Competitions (in Tashkent, Baku and Pesaro) and European Championships in 2021 were examined.

The number and rate of use of the preferred side in the movements they perform with their hands and feet/legs in body difficulties (jumps/leaps (take off foot), balances (support foot) and pivots/rotations (support foot) and in apparatus difficulties, dynamic elements with rotation and dance steps combinations (small, medium and high throws and catches) without major execution technique mistakes (such as loss of apparatus, loss of balance with fall) were determined. The RG evaluation rules (FIG, RG-CoP, 2017) were taken into account in the analysis of all body and apparatus movements. The combined body difficulties made up of the two movements were evaluated separately, while throws and catches performed with both hands and feet/legs, with any part of the body except the extremities, and jumps made with both feet with take off and landing were not included in the study. Since the club is a double apparatus, throwing and catching with both hands at the same time were included in the study. The catching hand was taken into account when a club was caught on the ground with another club in the other hand (the hand that carries aclub to catch a club).

The data were obtained by analyzing the routines recorded during the competitions. The latest routines of gymnasts who participated in more than one competition were included in the research. An analysis of all competition routines was conducted and evaluated at the same time by three RG judges, one of whom is international, and recorded with the symbolic writing used in the sport (FIG, RG-CoP, 2017). When there was a difference in analysis (symbolic writing) among the judges, the video recording of the competition routine was slowed down and movements were compared and rechecked. Descriptive statistical analyzes of the data were made by using the IBM SPSS 25.0 statistical program.

RESULTS

The usage numbers and rates of individual elite gymnasts' preferred side (right or left) in the final competitions (hoop, ball, clubs and ribbon) in throws and catches with hand and foot/leg in apparatus difficulties, and jumps/leaps, balances, pivots/rotations in body difficulties are given in Table 1, 2 and Figure 1, 2, 3.

In all routines, hand throws had higher rates of between 67.1% and 87% for the right hand; the highest rate was observed in the ball routines and the lowest rate was observed in the clubs routines. Left hand throws were higher in the clubs routines than in other apparatuses. The highest

mean values in the number of throws were seen in the clubs routines, i.e., 17.8 ± 3.3 with the right hand and 8.7 ± 2.1 with the left hand (Table 1, 2 and Figure 1). In catching by hand, higher rates of between 56.2% and 85.8% for the right hand as opposed to the left hand were observed. While the highest rate was observed in the ball routines, the values for the clubs and ribbon routines were close to each other, but lower than for the hoop routines. The right and left hand catching rates in the clubs and ribbon routines were closer to each other when compared to the other routines. The highest mean values in the number of catches were seen in the clubs routines, i.e., 15.0 ± 4.1 for the right hand and 11.5 ± 2.9 for the left hand (Table 1, 2 and Figure 1).

In all routines, while higher rates for the left foot/leg were found (69.3% and 74.2%) in the hoop and ribbon routines respectively in throws with a foot/leg, the right foot/leg ratios were found to be higher in the ball and clubs routines. The highest mean values in throws were observed in the ribbon routines (1.0 ± 1.4 in the right foot/leg) and in the hoop and ribbon routines (2.7 ± 1.7 in the left foot/leg) (Table 1, 2 and Figure 2). In all routines, the highest rates of catching with feet/legs were observed in the right and left feet, i.e., 49.6% and 39.3%, in the hoop routines respectively. The lowest rates for catching with right and left feet/legs were observed in the ribbon routines. The highest mean values in the number of catchings were observed in the hoop routines: 1.1 ± 0.9 for the right foot/leg and 1.0 ± 1.0 for the left foot/leg (Table 1, 2 and Figure 2).

In body difficulties in all routines, while left foot preference was observed in between 65.1% and 97.4% of jumps/leaps (take of foot) and in between 58% and 71.1% of balances (supporting foot), the right foot preference was higher in pivots/rotations (supporting foot), ranging from 72.6% to 80%. The right foot jumps/leaps had the highest rate in hoop routines; the left foot jumps had the highest rate in ribbon routines; right foot balance had the highest rate in clubs routines; left foot balance had the highest rate in hoop routines; right foot rotations had the highest rate in clubs routines, and left foot rotations had the highest rate in ribbon routines. The highest mean values in the number of uses related to jumps/leaps and balances were observed in the left foot, i.e., 3.5 ± 1.9 in ribbon routines and 2.5 ± 1.4 in ball routines. The highest mean values in the number of uses related to pivots/rotations were observed in the right foot , i.e., 3.3 ± 1.5 in ball routines (Table 1, 2 and Figure 3).

Table 1
Descriptive statistics of Hoop and Ball routines.

	Hoop (n=18)					Ball (n=17)				
	%	**x̄ and SD**	**Median**	**Min**	**Max**	**%**	**x̄ and SD**	**Median**	**Min**	**Max**
↗ **RH**	86.6	8.2 ± 2.9	8.0	3.0	15.0	87.0	11.4 ± 3.1	12.0	7.0	16.0
↗ **LH**	13.4	1.3 ± 1.2	1.0	0.0	4.0	13.0	1.5 ± 0.9	1.0	0.0	3.0
↓ **RH**	72.2	6.8 ± 3.1	6.0	2.0	12.0	85.8	9.0 ± 3.2	9.0	4.0	16.0
↓ **LH**	27.8	2.3 ± 1.6	2.0	0.0	6.0	14.3	1.5 ± 1.0	1.0	0.0	4.0
↗ **RF**	30.7	0.9 ± 0.8	1.0	0.0	3.0	52.4	1.0 ± 1.0	1.0	0.0	3.0
↗ **LF**	69.3	2.7 ± 1.7	2.5	0.0	6.0	24.0	0.5 ± 0.7	0.0	0.0	2.0
↓ **RF**	49.6	1.1 ± 0.9	1.0	0.0	3.0	14.7	0.2 ± 0.4	0.0	0.0	1.0
↓ **LF**	39.3	1.0 ± 1.0	1.0	0.0	3.0	20.5	0.2 ± 0.4	0.0	0.0	1.0
⌒ **RF**	34.9	1.2 ± 1.2	1.0	0.0	4.0	10.0	0.4 ± 0.6	0.0	0.0	2.0
⌒ **LF**	65.1	2.3 ± 1.7	2.0	0.0	6.0	90.0	2.2 ± 1.3	2.0	1.0	5.0
⊤ **RF**	28.9	1.2 ± 1.2	1.0	0.0	5.0	36.9	1.5 ± 1.0	2.0	0.0	3.0
⊤ **LF**	71.1	2.4 ± 1.0	2.0	1.0	4.0	63.1	2.5 ± 1.4	2.0	1.0	6.0
RF	78.4	2.9 ± 1.4	2.5	0.0	6.0	76.4	3.3 ± 1.5	3.0	1.0	6.0
LF	21.6	0.8 ± 0.8	1.0	0.0	3.0	23.6	1.1 ± 1.1	1.0	0.0	4.0

n; *Number of routines,* ***%;*** *preference rates,* ***x̄ and SD;*** *mean and standard deviation,* ***Min;*** *minimal values,* ***Max;*** *maksimal values,* ***RH;*** *right hand,* ***LH;*** *left hand,* ***RF;*** *right foot,* ***LF;*** *left foot, ↗ ; throws, ↓ ; catches, ⌒; jumps/leaps,⊤; balances, ; pivots/rotations.*

Table 2
Descriptive statistics of Clubs and Ribbon routines.

	Clubs (n=21)					Ribbon (n=19)				
	%	**x̄ and SD**	**Median**	**Min**	**Max**	**%**	**x̄ and SD**	**Median**	**Min**	**Max**
↗ **RH**	67.1	17.8 ± 3.3	19.0	11.0	23.0	78.4	7.6 ± 2.7	8.0	4.0	12.0
↗ **LH**	32.9	8.7 ± 2.1	9.0	5.0	12.0	21.6	2.1 ± 1.3	2.0	0.0	4.0
↓ **RH**	56.4	15.0 ± 4.1	15.0	7.0	25.0	56.2	7.5 ± 2.4	8.0	3.0	12.0
↓ **LH**	43.6	11.5 ± 2.9	11.0	6.0	18.0	43.8	5.9 ± 2.7	6.0	2.0	11.0
↗ **RF**	56.3	0.7 ± 0.6	1.0	0.0	2.0	25.8	1.0 ± 1.4	0.0	0.0	4.0
↗ **LF**	19.8	0.3 ± 0.6	0.0	0.0	2.0	74.2	2.7 ± 1.7	3.0	0.0	7.0
↓ **RF**	38.8	0.5 ± 0.6	0.0	0.0	2.0	5.2	0.05 ± 0.2	0.0	0.0	1.0
↓ **LF**	23.8	0.3 ± 0.5	0.0	0.0	1.0	5.2	0.05 ± 0.2	0.0	0.0	1.0
⌒ **RF**	9.8	0.3 ± 0.6	0.0	0.0	2.0	2.6	0.1 ± 0.3	0.0	0.0	1.0
⌒ **LF**	90.2	2.7 ± 1.4	3.0	0.0	5.0	97.4	3.5 ± 1.9	3.0	1.0	8.0
⊤ **RF**	42.0	1.4 ± 1.1	1.0	0.0	4.0	36.6	1.1 ± 0.8	1.0	0.0	3.0
⊤ **LF**	58.0	1.9 ± 1.1	2.0	0.0	5.0	63.4	2.0 ± 1.2	2.0	0.0	4.0
RF	80.0	2.8 ± 1.2	2.0	0.0	5.0	72.6	2.6 ± 0.8	2.0	2.0	4.0
LF	20.0	1.9 ± 1.2	0.0	0.0	4.0	27.4	1.3 ± 1.3	1.0	0.0	4.0

n; *Number of routines,* ***%;*** *preference rates,* ***x̄ and SD;*** *Mean and Standard Deviation,* ***Min;*** *minimal values,* ***Max;*** *maksimal values,* ***RH;*** *right hand,* ***LH;*** *left hand,* ***RF;*** *right foot,* ***LF;*** *left foot, ↗ ; throws, ↓ ; catches, ⌒; jumps/leaps,⊤; balances, ; pivots/rotations*

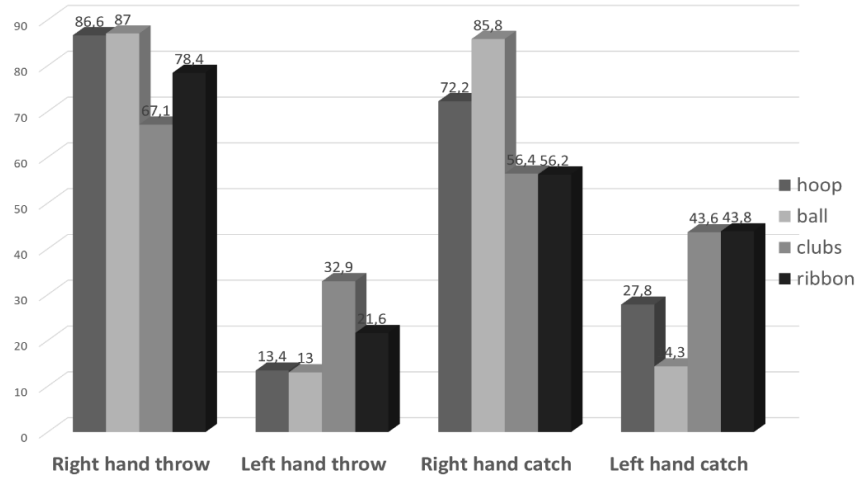

Figure 1. Right and left hand throwing and catching rates according to routines.

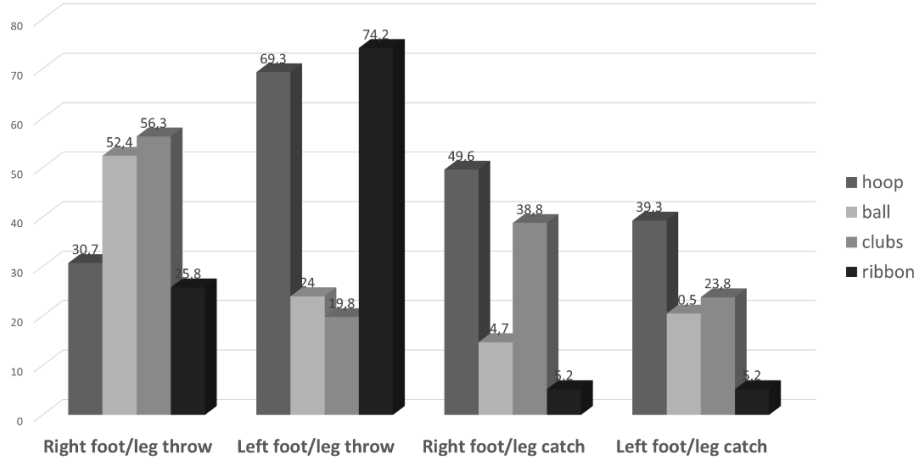

Figure 2. Right and left foot/leg throwing and catching rates in each routine.

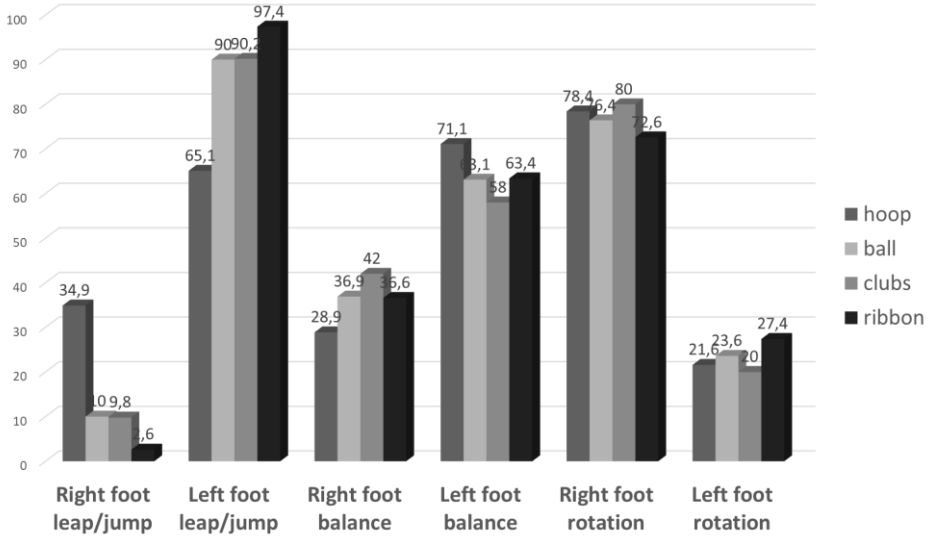

Figure 3. Right and left foot preference rates in body difficulties.

DISCUSSION

RG abilities and skills are quite complex. They not only include body movement techniques but also physical fitness and elegant and artistic presentation (Jastrjembskaia, & Titov, 1999). Gymnasts perform their movements (steps, hops, tabs, gallops, swings, circles, figure of eights, rolls, bounces, body waves, jumps/leaps, balances, rotations, throws and catches etc.) at different speeds, planes, axes and levels according to the rules of evaluation. In the process from learning the movements to their perfect presentation with music, repetitions can cause unilateral use of body parts. Unilateral works can lead to asymmetry in physical characteristics (such as anthropometry) and physical abilities (such as strength, flexibility, balance), and over time, musculoskeletal problems may develop. It has been stated that the movement symmetry can improve the technique, reduce the physical loads on the dominant limbs and prevent injuries (Starosta, 2018). Symmetrical trainings practised from the early stages of physical preparation not only can protect the health of the athlete, but can also increase the variety of movements during the specialization periods and contribute to the holistic beauty of the composition. In this study, we wanted to determine the number and ratio of hand-foot/leg preferences in movement difficulties used by senior elite rhythmic gymnasts in their final routines.

A gymnast may use her right hand/foot predominantly in her daily life activities, but she can also use her left hand/foot in RG movements or choreography. That is, sometimes the preferences can be sport-specific. Elite athletes are the people who represent the movement culture of the sport branch perfectly. Therefore, in our study we wanted to investigate these preferences/tendencies in gymnasts competing in finals.

In our study, the right-hand preference was observed in hand throws in all aparatuses, and the highest rate was observed in the ball routines. The highest rate in left-handed throws was observed in the clubs routines (Table 1, 2 and Figure 1). Apparatuses in RG are known as single (hoop, ball, ribbon) or double (rope, clubs). The reason why the rate of left-hand use is higher in the clubs routines when compared to the others may be due the fact that the clubs are a double apparatus and allow gymnasts to use both hands in their compositions. The highest mean values in the number of throws were again seen in the clubs routines (17.8 ± 3.3 in the right hand and 8.7 ± 2.1 in the left hand (Table 1, 2 and Figure 1)). In order to increase the total difficulty score by achieving a good score in apparatus difficulties, gymnasts tend to increase the number of elements in the clubs apparatus.

When the innate and acquired components of motor asymmetry are taken into consideration, the importance of using the right and the left arm in RG competition compositions increases since motor asymmetry may increase or decrease (Jastrejevskaya, 1995). In this study, in catches with hand, higher rates were found (between 56.2% and 85.8%) for the right hand. While the highest rate was observed in the ball routines, the values for the clubs and the ribbon routines were similar yet lower than the hoop routines. The lowest rate of left-handed catches was observed in the ball routines. In ball routines, catches can be performed with body parts (back, waist, knees, both feet, side of the waist, abdomen, under the legs, between the neck/nape and shoulders, etc.). Gymnasts may have preferred different catch styles as they would give them a variety of motion. The highest mean values in the number of catches were observed in the clubs routines (15.0 ± 4.1 for the right hand and 11.5 ± 2.9 for the left hand (Table 1, 2 and Figure 1)). The reasons of this may be due to the clubs being a double-apparatus and gymnasts'

desire to increase their apparatus difficulty score.

In our study, while higher rates were observed in foot/leg throws (in all routines), i.e., 69.3% and 74.2% in the left foot/leg in the hoop and the ribbon routines respectively, the right foot/leg ratios were higher in the ball and the clubs routines. It is thought that gymnasts make these choices due to the structural features of the apparatus and choreographic requirements. The characteristics of the apparatus (weight, size and shape) used in RG are different from each other, and these differences may also affect the movement patterns and extremity preferences.

In foot/leg catches, the highest rates were observed in the right and the left feet in the hoop routines, 49.6% and 39.3%, respectively (Table 1, 2 and Figure 2). The structural feature of the hoop apparatus may enable catching either with the right or the left foot. The lowest rates for catching with both feet/legs were observed in the ribbon aparatus. Because the ribbon aparatus is long (6m) and difficult to control, the gymnasts may not have wanted to make a mistake by risking catching it with their feet. In the evaluation rules, the penalty for loss of apparatus is high. That's why gymnasts do a lot of throwing and catching repetitions in training practice for perfect timing. Special exercises (such as catching with eyes closed, using a double tool, or using a double tool of different weights and lengths) to improve the catching skills are also practiced in the preparatory training. However, in order to get a good score, generally the side on which mistakes are fewer is preferred.

The number of repetitions of movements, parts and routines in training is evaluated and recorded by coaches. In the training analyses of the competition period, the gymnasts performed routine repetitions 16-30 times in each training with 2 or 4 apparatuses per day (Jastrjembskaia, & Titov, 1999). These repetitions may cause stress in the musculoskeletal system and asymmetry may develop. There are studies on asymmetry in the literature and attention has been drawn to these problems. In their study, Radaš and Bobić have emphasized that bad scoliotic posture may be more common in rhythmic gymnasts, and some sport-specific postural problems may develop due to an asymmetric overload, with continuous use of the dominant hand as one of the possible causes (Radaš, & Bobić, 2011). A ten times higher incidence of scoliosis has been found in rhythmic gymnasts than in their non-trained peers, and researchers have observed a significant physical load with persistently repeated asymmetrical stress on their spine (Tanchev, et al., 2000). In another study focusing on functional asymmetry and aiming to find out which flexibility variables better determine performance, gymnasts were observed to have 69.4% and 71.4% functional asymmetry in passive and active flexibility, respectively (Batista et al. 2019). In a review examining the relationships between asymmetry and athletic performance, these issues were comprehensively addressed (Maloney, 2019).

When we examined the hand and foot/leg usage preferences in body difficulties in this study, we found between 65.1% and 97.4% preference in the left foot in jumps/leaps and between 58% and 71% in balances. The right foot preference was found to be higher than for the other foot, with a changing ratio of 72.6% to 80% in pivots/rotations. Although some body difficulties are embedded in the movement culture of rhythmic gymnastics, athletes prefer the side on which they can perform most accurately. Differences in technical skill between the two sides of the body are disadvantageous because athletes may later become dependent on the preferred or dominant extremities (Parrington, & Ball, 2016). In senior category (FIG, RG-CoP, 2017), a total of 3-9 body difficulties including at least 1 jumps/leaps, 1 balance and 1 rotation in each routine are required, and gymnasts can use their body

difficulties that they can perform well more than once. Since low valued (0.10 points) body difficulties in aparatus difficulties were also included in the study, the number of body difficulties was found to be high (Table 1, 2 and Figure 3).

A rhythmic gymnastics competition has its own classification. All gymnasts participate in Competition I - Qualifications, and in Competition I, the best 8 athletes in each apparatus compete again in the finals (Competition III). In this study, the routines of top elite gymnasts who reached the finals in four major competitions were examined. If all the gymnasts participating in these competitions (Competition I - Qualifications) had been analyzed, the results might have been slightly different. These analyses can identify trends in the development of the performance structure. Undoubtedly, further studies are needed to evaluate these issues.

RG used to be a sport in which mainly females were interested, but nowadays we can see that men also participate in competitions. All gymnasts participating in the competitions in our study were females and we could not find any laterality research by gender regarding our subject in the literature, so its discussion was limited. However, it was noted in a previous study that females tend to be more lateralized, that is, more right-handed or more left-handed, than males (Tan, 1988). It has also been noted that sport-specific laterality evaluation results may show certain laterality distributions that may be inconsistent when compared to hand preferences (Loffing et al. 2014).

Obviously, training for gymnasts should be well-designed in terms of providing a recognition for their neural pathways, which is highly crucial for a long-lasting career. The central nervous system is an important complex network of components. Upper motor neurons, one of the components of the central nervous system, further subdivide into multiple tracts, each of which has specific functions within the body. Specifically, the pyramidal tract is the main pathway that carries signals for voluntary movement (Lohia, & McKenzie, 2022). In this study, a cross-sectional study of the gymnasts' preferred side in apparatus and body difficulties was conducted, and their number and ratios were determined. Why an athlete prefers one side of her body while performing these movements, and the neural control mechanisms depending on this preference can be further investigated with advanced laboratory studies (such as electrophysiological studies) in the future.

The results of this study contribute to our better understanding of certain features of high-level competitive routines. Its aim is to inform athletes so that they can continue their sports career in a healthy way for many years. There are explanations for the use of the non-dominant body part in the evaluation rules (FIG, RG-CoP, 2017). However, some adjustments to the evaluation rules or the methods that coaches will use can optimize the design of training. With this awareness, sports clubs can implement specific organizational and intervention strategies based on research.

CONCLUSION

In RG, pedagogical effects, habits, structural features of the apparatus, choreographic requirements, tendency to increase the difficulty score can affect the preferences of using hands, feet/legs. Gymnasts showed a tendency to use the right hand predominantly in throws and catches, the left foot in jumps/leaps and balances, and the right foot in rotations. From the very early stages of the physical preparation of the gymnasts, symmetrical trainings for apparatus and body difficulties should be included. This study may offer a different perspective to reduce injuries. The skill development of the non-dominant side can both protect the gymnast's health and

contribute to the beauty of composition in terms of movement variety.

REFERENCES

Batista Santos, A., Bobo Arce, M., Lebre, E., & Ávila-Carvalho, L. (2015). Flexibility in Rhythmic Gymnastics: Functional Asymmetry in Portuguese Junior Gymnasts. *Apunts. Educación Física y Deportes, 120*, 19-26. https://doi.org/10.5672/apunts.2014-0983.es.(2015/2).120.03

Batista, A., Garganta, R., & Ávila-Carvalho, L. (2019). Flexibility and functional asymmetry in rhythmic gymnastics. *Athens Journal of Sports*, 6(2), 77-94.

Castañer, M., Andueza, J., Hileno, R., Puigarnau, S., Prat, Q., & Camerino, O. (2018). Profiles of motor laterality in young athletes' performance of complex movements: merging the MOTORLAT and PATHoops Tools. Frontiers in psychology, 9, 916.

Cochet, H. & Byrne, R.W. (2013). Evolutionary origins of human handedness: evaluating contrasting hypotheses. *Anim. Cogn.* 16, 531–542.

Elias, L. J., Bryden, M. P., & Bulman-Fleming, M. B. (1998). Footedness is a better predictor than is handedness of emotional lateralization. *Neuropsychologia*, 36(1), 37-43.

Elliott, D., & Roy, E. A. (1996). Manual asymmetries in motor performance. CRC Press.

Faurie, C., & Raymond, M. (2004). Handedness frequency over more than ten thousand years. Proceedings of the Royal Society of London. Series B: Biological Sciences, 271(suppl_3), S43-S45.

Faurie, C., Raymond, M., & Uomini, N. (2016). Origins, development, and persistence of laterality in humans. In F. Loffing, N. Hagemann, B. Strauss, & C. MacMahon (Eds.), *Laterality in sports: Theories and applications* (pp. 11–30). Elsevier Academic Press.

Federation Internationale De Gymnastique (FIG), (2017). *Code de pointage GR 2017-2020*, Version mise à jour valable dès le 1er février 2018.

Frutuoso, A. S., Diefenthaeler, F., Vaz, M. A., & Freitas, C. (2016). Lower limb asymmetries in rhythmic gymnastics athletes. *International journal of sports physical therapy*, 11(1), 34-43.

Gilbert, A. N., & Wysocki, C. J. (1992). Hand preference and age in the United States. *Neuropsychologia*, 30(7), 601-608.

Heinen, T., Bermeitinger, C., & von Laßberg, C. (2016). Laterality in individualized sports. In F. Loffing, N. Hagemann, B. Strauss, & C. MacMahon (Eds.), *Laterality in sports: Theories and applications* (pp. 227-247). Elsevier Academic Press.

Hutchinson, M. R. (1999). Low back pain in elite rhythmic gymnasts. *Medicine & Science in Sports & Exercise*, 31(11), 1686-1688.

İpek, F., Doğan, M., Yıldı1z Kabak, V., Atasavun Uysal, S., & Düger, T. (2021). Cross-cultural adaptation, validity and reliability of Turkish version of the Waterloo Handedness and Footedness Questionnaire-Revised. *Laterality*, 26(6), 624-644.

Jastrejevskaya, N. (1995). Rhythmic Sportive Gymnastics. Theory and Practice, FIG, 477-524.

Jastrjembskaia, N., & Titov, Y. (1999). Rhythmic gymnastics. Human Kinetics 127-227.

Kalaycıoğlu, C., Kara, C., Atbaşoğlu, C., & Nalçacı, E. (2008). Aspects of foot preference: Differential relationships of skilled and unskilled foot movements with motor asymmetry. *Laterality*, 13(2), 124-142.

Loffing, F., Hagemann, N., Strauss, B., & MacMahon, C. (Eds.). (2016). Laterality in sports: Theories and applications. Elsevier Academic Press.

Loffing, F., Sölter, F., & Hagemann, N. (2014). Left preference for sport tasks does not necessarily indicate left-handedness: sport-specific lateral

preferences, relationship with handedness and implications for laterality research in behavioural sciences. PloS one, 9(8), e105800.

Lohia, A., & McKenzie, J. (2019). *Neuroanatomy, pyramidal tract lesions.*StatPearls Publishing, Treasure Island.

Maloney S. J. (2019). The relationship between asymmetry and athletic performance: A critical review. *Journal of strength and conditioning research*, *33*(9), 2579–2593.

Musalek, M. (2015). Skilled performance tests and their use in diagnosing handedness and footedness at children of lower school age 8–10. Frontiers in Psychology, 5, 1513.

Oldfield, R. C. (1971). The assessment and analysis of handedness: the Edinburgh inventory. *Neuropsychologia*, 9(1), 97-113.

O'Neill, D. B., & Micheli, L. J. (1988). Overuse injuries in the young athlete. *Clinics in sports medicine*, *7*(3), 591–610.

Parrington, L., & Ball, K. (2016). Biomechanical considerations of laterality in sport. In F. Loffing, N. Hagemann, B. Strauss, & C. MacMahon (Eds.), *Laterality in sports: Theories and applications* (pp. 279-308). Elsevier Academic Press.

Peters, M. (1988). Footedness: asymmetries in foot preference and skill and neuropsychological assessment of foot movement. Psychological bulletin, 103(2), 179.

Peters, M., Reimers, S., & Manning, J. T. (2006). Hand preference for writing and associations with selected demographic and behavioral variables in 255,100 subjects: the BBC internet study. *Brain and cognition*, 62(2), 177-189.

Prieur, J., Barbu, S., & Blois-Heulin, C. (2017). Assessment and analysis of human laterality for manipulation and communication using the Rennes laterality questionnaire. *Royal society open science*, 4(8), 170035. http://dx.doi.org/10.1098/rsos.170035

Radaš, J., & Bobić, T. T. (2011). Posture in top-level Croatian rhythmic gymnasts and non-trainees. *Kinesiology*, 43(1).

Sainburg, R. L. (2016). Laterality of basic motor control mechanisms: Different roles of the right and left brain hemispheres. In F. Loffing, N. Hagemann, B. Strauss, & C. MacMahon (Eds.), *Laterality in sports: Theories and applications* (pp. 155-177). Elsevier Academic Press.

Starosta, W. (2018). Movements symmetrization – an effective method of injury prevention, health strengthening and prolonged sport careers of athletes. In M. Baić, W. Starosta, P. Drid, J. M. Konarski, T. Krističević & N. Maksimović (Eds.), Movement in human life and health, Proceedings of the *14th International Scientific Conference of Sport Kinetics,* 24-27 june, p.35, Poreč, Croatia.

Tan, U. (1988). The distribution of hand preference in normal men and women. *The International journal of neuroscience*, *41*(1-2), 35–55.

Tanchev, P. I., Dzherov, A. D., Parushev, A.D., Dikov, D. M., & Todorov, M. B. (2000). Scoliosis in rhythmic gymnasts. *Spine*, *25*(11), 1367-1372.

Utesch, T., Mentzel, S. V., Strauss, B., & Büsch, D. (2016). Measurement of laterality and its relevance for sports. In F. Loffing, N. Hagemann, B. Strauss, & C. MacMahon (Eds.), *Laterality in sports: Theories and applications* (pp. 65–86). Elsevier Academic Press.

Zetaruk, M. N., Violán, M., Zurakowski, D., Mitchell, W. A., & Micheli, L. J. (2006). Injuries and training recommendations in elite rhythmic gymnastics. *Apunts. Medicina De L'esport*, *41*, 100-106.

Ziyagil, M. A. (2011). Handedness and footedness: relations to differences in sprinting speed and multiple sprints performance in prepubertal boys. *Perceptual and motor skills*, 112(2), 440-450

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Article received: 10.6.2022
Article accepted: 26.1.2023

LIVED EXPERIENCES OF PARTICIPANTS IN THE WORLD GYMNAESTRADA: RECOGNIZING "FOR ALL"

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Original article *DOI:15.1.109 - 119*

Abstract

Participation in events is about experiences. These experiences are unique to individuals. From phenomenology, as we live the world, we get to know things and others. This process constructs our identity and expands our being-in-the-world. This article aims to reflect on the lived experiences of 16 participants of a Gymnastics for All (GfA) team at the XVI World Gymnaestrada (WG) event. Observations and in-depth interviews were used, on which phenomenological analysis was performed. The validity and trustworthiness were guaranteed by having a critical friend, member review and data triangulation. The results showed that even when having previous information about the event, the gymnasts and staff did not have the real dimension of WG. This recognition came by being there. They pointed out that it was not just about the high number of people - it was about different people coming together; it was not about a specific discipline of gymnastics but rather all disciplines together; not about the traditional gymnastics apparatus but rather gymnastics using diverse artifacts. For them, the plurality of GfA came alive in the movements, performances, themes, and profiles of the gymnasts. It made them believe they were gymnast. In addition, reflections on a sporting event with no competition and the professional development were recorded. Managing, studying, and researching GfA is important. However, promoting lived experiences in gymnastics events should also be valued as an effective learning space, enchantment, and promotion of GfA.

Keywords: *gymnastics; sporting events; qualitative research.*

INTRODUCTION

Lived experience has been an important aspect when discussing events (Biaett & Richards, 2020; Armbrecht & Andersson, 2019; Yazici, Koçak & Altunsöz, 2016). Cudny (2014, p. 643) notes that "a festival is an organized socio-spatial phenomenon, taking place at a specially designated time, outside the everyday life, shaping social capital and celebrating elements of tangible and intangible human culture". Furthermore, Gibson and Stewart (2009) refer to the festivals as "a point of convergence" that provide opportunities for meetings and networking between people interested in the same activity.

Different professionals focus attention on understanding festivals and their consequences. Managers and sponsors are interested in knowing how an event affects its participants in order to deliver memorable experiences to individuals, assessing their motivations and the likelihood of them returning to the event. (Richards, 2019; Morgan, 2008). On the other hand, in Physical Education and Sports, our interest in festivals is related to their pedagogical aspects, especially long-term athlete development (Barreiros, Coté

& Fonseca, 2013), since lived experiences in sporting events can positively or negatively influence an athlete's development (even on a high and/or formative level).

To better understand lived experiences in events, our approach focuses on phenomenology, as it gives us a chance to describe the perception of experiences themselves. Indeed, it guides us to analyze the phenomenon as it was. Following the paradigm of the body as a corporeity, in contrast to the body as a machine, it includes human subjectivity and embodiment in a context-dependent manner.

Phenomenology is a philosophical movement that began in the 20th century; one of its forefathers was Edmund Husserl (1859-1938). The philosopher speaks of "opening ways" to unveil the reality of things through their essences. Experience, seen from the perspective of phenomenology, employs a reflection that includes observing phenomena (things) and the way they manifest themselves (Martins, Boemer & Ferraz. 1990). Our ability to obtain insights or empirical data is, for Husserl (2002), the experience itself. There is, therefore, a relationship between the object — as it shows itself — and how it is "captured" by consciousness. Phenomenology is not about explaining or analyzing the phenomenon, it is about describing it or returning to the things themselves — that is, as they appear in the world.

In this sense, Merleau-Ponty begins the process of reflection that asks questions such as: What "touches us most"? What "touches us first"? What "affects us most"? Does our perceptions of things come to us through sensitivity or our already elaborated thinking? And to Merleau-Ponty (2018), perception is our first contact with things, and it is through a sensitive relationship that we recognize them before an elaboration of theoretical thought or practical use.

Participation in events is about experiences. These experiences are unique to individuals. From the phenomenological point of view, as we live and experience the world, we get to know things and others. This process constructs our identity and expands our being-in-the-world (Bauman, 2005).

Understanding "perception" as a mix of what is seen and what is intended by us, we endorse that every experience involves the relation between presence and absence. A great example of this discussion is taking part in a sporting event: we have intentions (think about, have ideas) about how it will be. We imagine the space, people, and feelings. As soon as we get to the event, the lived experience – until then abstract – comes to the body, i.e., is being experienced. The event's identity will be built within what is experienced. Thus, an event is perceived from different perspectives by one single person, or many people, but will always be the same event that will be given as it is (Sokolowski, 2014).

Such perceptions, although unique to each person, can indicate pedagogical, affective, administrative, and strategic possibilities, among other areas, that all comprise the events in general.

Considering the possibilities of sporting events, we bring light to the gymnastics festivals. Considered a sporting event, a gymnastics festival is known for having gymnastics movement as the baseline of what is performed. It can focus on competition – ranking the athletes, having first, second and third place, judges and/or evaluators - or essentially having a festive atmosphere, such as a contest – where there is no evaluation, or the evaluation is minimal and has a purpose, or just brings people together. Both events can be considered "participant events" from Getz's (2012) perspective since the participants do the performances but are also spectators to each other.

Gymnastics for All (GfA) is a practice that essentially does not focus on high-level

athletes and competition events, such as championships. Mainly, it brings to life the idea of gymnastics for life, a of having an active life, and moving one's body (performing) in a way that invokes gymnastics identity.

GfA is recognized by the International Gymnastics Federation (IGF) as an activity that should form the basis of the gymnastics pyramid; in other words, it should offer a wide variety of gymnastics movements for everyone. Elderly, disabled people, men and women, and people with or without gymnastics background, people of all ethnicities and body shapes are welcome to the gym. It is the opposite side of early specialization, as its training sessions include the foundations of gymnastics: landing, rotation, support, balance and suspension; combining the process of teaching and learning these foundations with fun – games and problem-solving, for example; the development of friendship - such as exercises in which the goal is to do something together with others, and/or organize spaces where people can socialize and make friends (going to sporting events, e.g.); and importantly, developing fitness - strength, flexibility, power, speed and coordination.

In addition, GfA events have been developed with different objectives, following political, tourist, and economic interests. Thinking from the pedagogical and sports perspective, these events also provide an opportunity to show performances, to see and be seen by peers as well as to increase social and personal development (Silva, Menegaldo & Bortoleto, 2021; Contessoto *et al.,* 2021; Patricio & Carbinatto, 2021; Carbinatto & Ehrenberg, 2020; Oliveira *et al.,* 2020; Patricio *et al.,* 2019; Patricio, Bortoleto & Carbinatto, 2016; Patricio & Bortoleto, 2015).

Even though there are many gymnastics for all events around the world (Patricio, Bortoleto & Carbinatto, 2016), there are just two of them organized by the FIG: World Gym for Life Challenge (WGfL, started in 2009) and World Gymnaestrada (WG, started in 1953). Both events focus on group performances (using or not using apparatus; including dance, folklore, etc.) and are held every four years. In WGfL, there are contests, and groups are evaluated/ranked in the first, the second and the third places (getting a medal as a prize). In WG, there is no direct evaluation and ranking of performances. In this way, it is known as a more massive event, with around 20 thousand people joining in.

This article reflects on the perceptions of experiences lived by adult participants in the XVI World Gymnaestrada, held in Austria (2019), especially focusing on the idea of "For All" inherent in the practice of GfA.

Participation in sporting events is an experience that is unique to individuals. However, understanding its values to individuals can sharpen their focus and bring these events to an even broader audience.

METHODS

The qualitative method was chosen for the data collection. Observations and in-depth interviews were used to access the lived experience of participants in the XVI World Gymnaestrada and perform a phenomenological analysis on it.

Sixteen adults took part in the study. They were from the same gymnastics group. Twelve were gymnasts (one male and eleven female) and four were spectators (we use the word "spectators" as per their official registration, but it is relevant to note that at WG, a spectator in a gymnastics team is very active. They follow the team backstage, share their accommodation, and help with their equipment. They can be compared to a sports team staff). The mean age was 35.9 years. To preserve their identity, we use pseudonyms.

Ethical approval for this study was obtained from the Ethics Committee of the University of São Paulo (33299620.9.0000.5391). A meeting was

held with the participants where an explanation of the research was provided. The Consent Ethical Forms were signed by each individual and then data collection took place.

The profile information of each participant was obtained by having a questionnaire answered by them individually.

The participant observations were systematically organized using field notes that started being collected six months before and during the event. The first author was the Group Leader of the gymnastics team during the event, as one of the coaches did not attend due to some personal issues and the other coach was in a managerial position during the event, therefore not being able to be with the team. This situation gave the principal researcher a broader possibility for collecting field notes, as she was aware of each member's travel, leisure plans and team's performances. Consequently, she collected data in many different situations, having privileged access to very particular situations.

The field notes were recorded and/or transcribed after every training session and/or team meetings, such as at the school accommodation, after breakfast, lunchtime, and others. Video/audio recordings were used when something interesting happened and the researcher did not have time and/or could not describe the situation in writing. After the data collection, they were transcribed.

Before the event, eleven regular training sessions and six extra training sessions were observed (40 hours and 30 minutes). During the event, the data were collected from the time when the team arrived in Austria (July 6th) until they travelled back home (July 13th).

Registered on a 53 Microsoft Word spreadsheet, the field notes were identified by date, situation, observations, memos, and a pre-analysis of the themes made by the main researcher.

The in-depth interviews started by asking the interviewees to bring artefacts from their experiences (Husserl, 2002). This included photos, objects, videos, or anything they wanted to show to the researcher. As soon as they explained why they chose each artefact, they brought light to the lived experience. This strategy guided them to express emotions and the relevant aspects of the lived experience.

The main question for each artefact was: "Tell me about what you have chosen to bring to the interview" which led the participant to express their own perceptions.

Each interview lasted approximately 45 minutes, resulting in 12 hours of recordings. The interviews were transcribed and a narrative from each interview was sent to each of the participants, so they could read and consent and validate the use of the data collected (Member Checking).

A 'natural attitude' (Sokolowski, 2014) was adopted to follow up the phenomenological analysis, 'keeping a distance from' and avoiding 'taken-for-granted' information about the lived experience to be able to describe its essential characteristics.

The following steps were taken, based on Giorgi (1985):

a. Collection of concrete 'naive' descriptions of the phenomenon from the participants.
b. Attentive reading of each description to have a feeling of the whole.
c. In-depth re-reading of each description to identify 'meaning units' which capture specific aspects of the whole.
d. In-depth reading of field notes and social media, and their relationship to the participants' discourses.
e. Organizing meaning units of each participant separately.
f. Identifying the significance of each meaning unit, noting similarities and differences.
g. The production of a general description of the structure(s) of the experience, with the phenomena speaking for themselves.

The validity and trustworthiness of this research were ensured by having a critical friend, a peer review and a member review. The critical friend was invited to follow the methods and every step (Stenhouse, 1975) and had more than ten years of GfA experience in different roles: as a coach, a researcher, and a manager. In addition, she participated in the XVI World Gymnaestrada.

A qualified researcher reviewed the findings by having access to the interviews and field notes to ensure that objectivity and thoroughness were achieved (Creswell & Poth, 2018). The reviewer provided comments that were taken into consideration by the researcher.

Member checking was conducted by sending the narrative of individual interviews to each participant, followed by a form where they could confirm (or not) its veracity.

Furthermore, we adopted the concept of 'triangulation', as we analyzed the phenomena from more than one source of information (Creswell & Poth, 2018).

RESULTS AND DISCUSSION

Different factors can determine the level of satisfaction when we reflect on the experiences. Circumstantial factors such as ethnicity, sex, age, marital status, health, and religion, among others, interfere with aspects of personal feelings (Armbrecht & Andersson, 2019). However, "intention factors" can explain another part of the satisfaction variation and are related to behavioral activities that we choose to have – relaxing, exercising, listening to music, and so on.

An affective contentment was noticed in the lived experiences perceptions in the WG. These perceptions were fulfilled by the characteristics of the event itself. Our interviews explained the eudaimonic component of satisfaction – based on the development of their potential and self-learning, related to personal development in response to being in the event (Armbrecht and Andersson, 2019). This means that our interviewees had a very personal prior interest, such as relaxing, exercising and/or listening to music.

a. Take advantage to travel abroad

Akanni: *"Well, I brought my passport to the interview because for us, Latin-Americans, it's not easy to go to Europe. It costs a lot of money. When I got my passport, I had that feeling of…not of being a winner, but of making a journey, a journey where I did not know where I would get. When Cecilia invited me to join the team to go to the WG, it was like "let's do it from here, from the WG door". So, it was a wonderful, long, and great journey, whose gateway was WG."*

b. Perform a routine with the team

Zoe: *"You want to do it well, don't you? I wanted to do my best! Despite my commitment in the rehearsals, I was anxious. Will the people like it? Even if it is not from the competitive perspective? Will they notice me? Will they think I perform well, even if they do not know the composition? We hope everybody likes it, gets into the mood of the music, and it finally catches them!"*

c. Watch different performances and learn from them

Alekena: *"At that moment, I had just started a new job as a teacher. So, I travelled thinking about not just being a gymnast, but also learning about creativity, getting ideas for a team that I would teach in the future: "Look at the apparatus, how nice! We can explore it! Possibility of costumes, clothes, movements, acrobatics, steps, dance, everything that we see that is very rich." So, it was an incredible opportunity to see it in real life. Before that, I watched it using Youtube®. Indeed, I was a gymnast, I was like them, and that was meaningful for me."*

In this sense, the intentionality of each participant is connected to their way of existing as "being-in-the-world". Each interviewee described their World Gymnaestrada lived experience with their

previous experiences and interests. However, they were also open to new ones.

The participants realized that the meaning of going to WG was not exclusively in what the festival represents – the biggest GfA event organized by the FIG. The gymnasts and staff did not have the perception of the real dimension of WG. This recognition came by being there:

Akanni: *"I had a very superficial knowledge of WG. Even the title "Gymnaestrada" does not give the real meaning to those who are not from the gymnastics field. I used to focus on the general aspect: it's a gymnastics event. I didn't pay attention to the number of people: 21.000 people! I had no idea how big it was!"*

Caio: *"This event is huge! I thought it was much smaller (...) but it was very big!"*

Iris: *"I will tell you how awesome it was (...). It was much more than I expected. Different levels of technique, some high level….and it was very beautiful and colorful, it was very happy, everyone had the same vibe!"*

The number of people and activities in the WG were noticed in the interviews, however, understanding GfA was more than that: the participants pointed out that it was not just about a lot of people - it was about different people coming together; it was not about a specific discipline of gymnastics, it was about all disciplines together, with dance, folklore, etc.; it was not the traditional gymnastics apparatus, it was gymnastics using a water bottle, beach accessories, inflatables sofas, etc.

In person, they could relate to the theory put to practice. As stated by Bento-Soares & Schiavon (2020), Menegaldo & Bortoleto (2020a), Carbinatto & Reis-Furtado (2019), the plurality of GfA was alive in the movements, group performances, themes, and profiles of the gymnasts. Not having a Code of Points and judgment, the WG event brought light to possibilities, creativity, and its massive base.

Shakira: *"[...] for me, the most interesting thing was to see that many different people were participating. Not just young people, such as our team, but adults, children, and a lot of elderly people! I was in shock at how there were old people performing movements even better than we did (laughing)! And disabled people. At WG, everybody was equal, regardless of their age or abilities. Everyone was united by gymnastics! In addition, the performances! We do not compete. We congratulate each other, and it does not matter what level of movements you displayed! (…). It was not about the feeling of being better than others."*

Cecilia: *"It's an event where people bring what they have…even when they think "maybe this is simple/nothing special", at WG it is super! Every single detail is yours. It's what you know! There is no room for bad feelings! For example, hostility, argument, there is no room! WG does not give room to that!"*

Alana: *"[...] today I noticed a different perspective, maybe focused on quality of life. It surprised me to watch many people, women, many women practicing and older women, some over fifty years old! And men too. It was cool!"*

The interviewees had previous knowledge about WG and its informal evaluation - no judges, for example - but living it gave them the experience of "participation".

It provided an ideological collapse of traditional models like "gymnastics bodies" – young, strong, and beautiful – that meet the demands of the culture and history of gymnastics (Soares, 2013). Finally, they understood that a body in movement can give us meaning and answer the question what is missing inside us. In gymnastics, a body in movement can find a challenge for desires and curiosities. Every gymnastics body in movement can give us a better understanding of the world and the sense of being-in-the-world.

Our research reveals a certain astonishment regarding the number of

elderly people at WG. This event was not just about those that had a gymnastics background or grew up as gymnasts, but also about people that are having an active life doing gymnastics. Research studies of the benefits of gymnastics for elderly have been growing in emerging countries, especially those that do not have this practice in their own culture (Contessoto *et al.,* 2021; Lopes & Santos, 2021; Silva, 2020; Oliveira *et al*., 2020; Moreno & Tsukamoto, 2018; Simões & Carbinatto, 2016).

Beside the idea of inclusion, GfA events – such as WG - can enhance individuality and contribute significantly to the formation of social environments that support the ageing process (Contessoto *et al,* 2021).

The cultural background of gymnastics in Europe (Patricio, Bortoleto & Carbinatto, 2016) influenced the number of teams where the elderly of both genders were practicing gymnastics in WG. Coming from a South American country where other types of cultural influences are stronger, and getting in contact with such traditional performances – such as a large group performance including more than 200 gymnasts, many of them adults and elderly - helped our participants to think "outside the box". From simple but synchronized steps and dance to risky acrobatic movements, the perception was that everybody could be included and do their best.

Cacilia's Field Note (July 12th, 2019): *"They were men, potbellied and white-haired. In a group of three, they were divided into the base, the supporter, and the top. As they helped each other to go up, an acrobatic pose was formed. Then, a mortal to undo the pose. My heart froze. Butterflies in the stomach! I was afraid that they would get hurt! Can you imagine my grandparents doing this? Right after, a feeling of peace and enchantment: it worked! They are fine and smiling! The performance was amazing!"*

With the use of technology and social media, we can access videos recorded with elderly gymnasts and their active life in gymnastics. However, in the WG it was possible to be with them and realize that it was not just about their high-level performance. Cecilia identified the power of collective actions by combining different techniques and potentializing what each of them could do. Additionally, understanding how culture and also public policies – e.g., relating to gymnastics – work can spread this practice worldwide and make really "for everyone".

As some of the interviewees were Physical Education teachers and/or Coaches (or about to become one or the other), going to the World Gymnaestrada underpinned their professional development. Among multiple other opportunities, the attentive professionals and students were looking for new ideas, concepts, movements, and transitions.

Cibele*: "WG was a game-changer for me. Before, I was a little raw in gymnastics. I was still only entering the gymnastics world. Arriving at the WG, watching and living the WG, made me saying to myself: "now you are a gymnast, now you are GfA, now you've lived it!". I lived it and now I have this experience to talk about (laughing). I have experienced a lot of events before, but WG for me was number one (very enthusiastic)."*

Alana: *"Gymnastics career is very exclusive, isn't it? I had many crises in the last years, about what to do professionally (...) I work with rhythmic gymnastics, but I'm in doubt if I want to carry on with it. So, coming to WG gave me time to breathe – think of new job fields, inside gymnastics, and new possibilities. To go back to my country and work in a different practice."*

Alekena stated that videos are a great strategy in the technological era, but should not come before being at the event. We are dealing with tangibles: bodies-in-the-world; embodied beings; bodies that relate to things and to others in the world; bodies that move and express themselves. Bodies that

need to touch and be touched, see and be seen, listen and be heard (Merleau-Ponty, 2018; 1984).

The incorporation of knowledge gained in the event is closely related to what phenomenology theory describes as the body being-in-the-world. We get to know things by experiencing them and we use our bodies as the main entrance to the experience. Contrary to the body-and-mind dualism, corporeity agrees that knowing, perceiving, feeling, watching, and seeing is about all together living in the world. It is not about having abstract information, but living it, as we live in the world. Nevertheless, if we reflect on coaches education and professional development, why do academic events count, and sporting events don't? Why do we encourage our Physical Education undergraduate students and/or coaches to listen to lectures and read articles, but do not encourage them to be part of gymnastics events in general?

It is complex to think about the teaching and learning process and we are aware that there are different ways and possibilities. It is not about the ranking of theory and practice and about where we learn more. Seeing this gymnastics event as a valuable place for "being-in-the-world-in-sport" and experiencing the practice, Sofia explained:

Sofia: *"I thought about the aesthetic aspect of sports. What was behind the shows? Because we do like to see aesthetic movements. An athlete flying higher, a child doing many flic-flacks. That gave me pleasure, the audience standing up and clapping their hands (…). Sports bring that! This excitement. So, I could understand that. Theory coming right in front of me. The sounds of happiness (she laughs). I was anesthetized by those performances. Of course, it has technique, identity, and training aspects, but in the GfA world. Japanese Night, for example, combining gymnastics with drums, sticks, and costumes. I could smell the cherry tree! It was memorable. And IGF Gala, John Lennon, and Gymnastics. The theme was "Gymnastics for Life". So, it is gymnastics from when you are born until you die, get old, and when you are pregnant. This is very meaningful."*

Sports should make it possible to move closer toward encounter, pleasure, playfulness, and overcoming inhibitions, rather than being exclusively linked to body control or the submission to gestural codes and dominant powers (Sobreira, Nista-Piccolo & Moreira, 2020). Thus, we agree with the understanding of sport according to Bento (2006, p.03):

"[...] a construct that is based on a pluralistic understanding and on a representative, aggregating, synthesizing, and unifying concept of biological, physical, motor, playful, bodily, technical and tactical, cultural, mental, spiritual, psychological, social and affective dimensions. The sporting act has all this implicit, without exhausting it. Thus, 'sport' has a broader and larger meaning, and not a reductive and minor one, like the one contained in the expression 'physical education', or 'movement', or other such things."

In this context, we understand that Gymnastics for All, as a bodily practice devoid of gestural and, essentially, participatory regulation, is part of the "sports" phenomenon, as Bento (2006, p.155) explains: "I understand sports as a set of bodily technologies, their use being guided by cultural reasons and patterns and by social intentions, goals and values".

Being at WG provided an unveiling of "self": bodies full of confidence but also full of doubts. Getting out of our routines and observing new approaches and possibilities can open our minds and lead us to rethink our patterns. It means being able to break the institutional ties and create alternatives in life, work, and relationships. It means having time to explore and discover new desires. It was evident that by taking part in WG and its different program activities, our participants experienced being gymnasts, but they also evolved as

gymnastics spectators, gymnastics coaches, gymnastics teachers and human beings.

CONCLUSIONS

Using the interview speeches and field notes, we were able to describe the perceptions of the XVI World Gymnaestrada of our participants. Between desires of self-fulfillment (such as an international trip) and idealizations of professional education, we reflected on the various intentions that permeated the sports team in their participation at the event.

Thus, the lived experience brought to the participants a better understanding of what Gymnastics for All means. Being a spectator and being a gymnast and/or being part of a gymnastics team provided situations that were seldom or never experienced before. Even with some prior knowledge (Higher Education Sporting Coaching program; Master's degree; national GfA events), what they have learned through being at the XVI World Gymnaestrada raised their understanding of GfA.

In the end, it was not about reading that the elderly can still engage in gymnastics. It was seeing them perform movements with a better technique than themselves. It was not about watching the use of a new apparatus. It was about being surprised by its originality. It was not about supporting the concept of disabled people experiencing gymnastics. It was putting them in the spotlight. It was not about theoretical approaches. It was about a lived gymnastics world that was experienced.

Therefore, managing, studying, and researching the GfA event is important. Promoting lived experiences in gymnastics events should be valued as an effective learning space, enchantment with, and support of GfA

REFERENCES

Armbrecht J & Andersson, T (2009). The event experience, hedonic and eudaimonic satisfaction and subjective well-being among sport event participants. *Journal of policy research in tourism, leisure and events*.

Barreiros, A; Coté, J & Fonseca, A. (2013). Sobre o desenvolvimento do talento no desporto: um contributo dos modelos teóricos do desenvolvimento desportivo. *Revista de Psicologia del Deporte.* 22(2): 489-494.

Bauman, c. (2005). Técnica e expressividade: análise fenomenológica do corpo na dança. *Motricidade,* v. 1, n. 1, pp. 62-70.

Bento, J. O. (2006). Corpo e Desporto: Reflexões em torno desta relação. In: Moreira, W. W. (org.). *Século XXI: a era do corpo ativo*. Campinas: Papirus.

Bento-soares, D & Schiavon. L. M. (2020). Gymnastics for All: different cultures, different perspectives. *Science of gymnastics journal,* v. 12, n. 1, p. 5-18.

Biaett, V & Richards, G. (2020). Event experiences: measurement and meaning. *Journal of policy research in tourism, leisure and events,* v. 12, p. 277-292.

Carbinatto, M.V & Reis Furtado, L.N. (2019). Choreographic process in gymnastics. *Science of gymnastics journal,* v. 11, n. 3, p. 343-353.

Carbinatto, M.V & Ehrenberg, M.C. (2020). *Festival Ginástico e Isolamento Social: retratos de um evento on-line.* Curitiba: Bagai.

Contessoto, G.S. de M; Menegaldo, F.R; Patricio, T.L & Bortoleto, M.A.C. (2021). Ginástica para Todos e Corpos Experientes: um diálogo entre a ginástica e outras práticas corporais. *Caderno de educação física e esporte.* V. 19, n. 2.

Creswell, J.W. & Poth, C.N. (2018). *Qualitative inquiry and research design choosing among five approaches*. 4th edition, sage publications, inc., thousand oaks.

Cudny, W. (2014). The phenomenon of festivals—their origins, evolution and classifications. *Anthropos,* n. 109(2), pp. 640–656.

Getz, D. (2012). *Event studies. Theory, research and policy for planned events*. Londres e Nova York: Routledge.

Gibson, C & Stewart, A. (2009). Reinventing Rural Places: The extent and impact of festivals in rural and regional Australia**.** *Research report. Australian Research Council*, University of Wollongong,.

Giorgi, A. (1985). Sketch of a psychological phenomenological method. In a. Giorgi (org.), *phenomenology and psychological research* (pp.8-22). Pittsburg: Duquesne University Press.

Husserl, E. (2002). *Idee per una fenomenologia pura e per una filosofia fenomenológica*. Turim: Einaudi.

Lopes, P & Santos, L.M.G. (2021). "Ginasticando na Melhor Idade": experiencias da Ginástica para Todos em um projeto de extensão universitária. *Licerce.* (Belo Horizonte) v. 24. N. 1.

Martins, J; Boemer, M.R & Ferraz, C.A. (1990). A fenomenologia como alternativa metodológica para pesquisa: algumas considerações. *Revista da escola de enfermagem da USP*, São Paulo, v. 24, n.1, pp. 139-147.

Menegaldo, F.R & Bortoleto, M.A.C. (2020). Ginástica para Todos: o que a Praxiologia Motriz tem a dizer sobre isso? *Conexões,* v. 18, ed. Esp.

Merleau-Ponty, M. (1984). *O olho e o espírito***. (**2. Ed.) São paulo: abril cultural. (Coleção Os Pensadores).

Merleau-Ponty, M. (2018). *Fenomenologia da percepção.* Tradução de Carlos Alberto Ribeiro de Moura. (5st ed.). Editora WMF Martins Fontes, São Paulo..

Moreno, N.L. & Tsukamoto, M.H.C. (2018). Influências da prática da ginástica para todos para a saúde na velhice: percepções dos praticantes. *Conexões*, v. 16, n. 4, (p. 468-487).

Morgan, M. (2008). What Makes a Good Festival? Undertanding the Event Experience. *Event management*, v. 12, p (p. 81–93).

Oliveira, J.S; Silva, F.S; Menegaldo, F.R & Bortoleto, M.A.C (2020). Ginástica para Todos: notas sobre a composição coreográfica por praticantes idosas. *Motricidades*, v. 4, n. 3.

Patricio, T.L & Bortoleto, M.A.C. (2015). Festivais Ginásticos: princípios formativos na visão de especialistas. *Conexões* (campinas), v. 13, (p. 98-114).

Patricio, T.L & Carbinatto, M.V. (2021). Merleau-Ponty e Ginástica para Todos: repensando paradigmas na Educação fiFsica/Esporte. *Conexões (*Campinas), v. 19, n. 1.

Patricio, T.L; Batista, M. S; Henrique, N.R; Reis-Furtado, L.N & Carbinatto, M.V. (2019). Do preparo à apresentação coreográfica em festivais de ginástica: análise dos caminhos traçados por um grupo de Ginástica para Todos. *Movimenta,* v. 12, (p. 632-647).

Patricio, T.L; Bortoleto, M.A.C & Carbinatto, M.V. (2016) Festivais de Ginástica no Mundo e no Brasil: reflexões gerais. *Revista Brasileira de Educação Física e Esporte* (São Paulo), v. 30, n. 1, (p. 199- 216).

Richards, G. (2019). Measuring the dimensions of event experiences: applying the event experience scale to cultural events. *Journal of policy research in tourism, leisure and events*.

Silva, F. S. (2020). *Contribuições da Ginástica para Todos para o desenvolvimento das relações sociais em idosos*. 2020. Dissertação (Mestrado em Educação Física) – Universidade Estadual de Campinas. Faculdade de Educação Física. Campinas.

Silva, F.S; Menegaldo, F.R. & Bortoleto, M.A.C. (2022). Ginástica para Todos: um olhar sobre o desenvolvimento das relações sociais em grupos de idosos. R. Bras. Ci. E mov./ *Brazilian Journal of Science and Movement*, 30(1). Issn: 0103-1716.

Simões, R. & Carbinatto, M.V. (2016). Ginástica para Todos: inclusive para o idoso! In: Miranda, R. C. F.; Ehrenberg, M. C. & Bratifische, S. A. (org.). *Temas emergentes em ginástica para todos*. Várzea Paulista: Fontoura,.

Soares, C.L. (2013). *Imagem da educação no corpo:* estudo a partir da ginástica francesa no século XIX. (4. Ed). Campinas: autores associados.

Sobreira, V; Nista-Piccolo, V.L. & Moreira, W.W. (2020). A Ciência do Desporto na perspectiva de Jorge Bento para a formação de professores de Educação Física. *Olhares e trilhas,* v. 22, n. 2.

Sokolowski, R. (2014). *Introdução à fenomenologia*. Tradução: Alfredo de Oliveira Moraes. (4a ed). São Paulo: Edições Loyola.

Stenhouse, L (1975). *An introduction to curriculum research and development*. Londres: Heinemann.

Yazici, T; Koçak, S. & Altunsöz, I.H. (2016). Examining the effect of experiential marketing on behavioral intentions in a festival with a specific sport event. *European sport management quarterly*, v. 17.

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Article received: 13.12.2022
Article accepted: 18.1.2023

DEMANDS STATED BY ARTISTIC GYMNASTICS COACHES AT THE BEGINNING OF THEIR CAREERS

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Original article *DOI: 150.1.121-131*

Abstract

High quality performance of sports coaches involves the use of professional, interpersonal and intrapersonal skills (Côté & Gilbert, 2009). The complexity of the work of sports coaches, especially in Artistic Gymnastics (AG), due to the profound technical and physical demands right from the basic categories, can be magnified for coaches with little experience entering the field. Thus, this study aimed to identify the perceptions of coaches at the beginning of their careers regarding the types of skills required for their professional routine. We interviewed five coaches affiliated with the Santa Catarina Gymnastics Federation (Brazil) with less than 10-year experience in AG. During the interviews, indicators, such as professional routine and knowledge required in this context, were addressed. We used Braun and Clarke's (2019) reflexive thematic analysis to analyze the data. The results show that the complexity of coaches' work requires an expanded repertoire of knowledge. In general, coaches realize that relevant professional and interpersonal skills to teach gymnastics are the most required types of knowledge in daily practice. Intrapersonal skills, on the other hand, seem to be less needed, which may contribute to the preservation of an authoritarian culture in sports training. The requirements discussed in this study lead to implications for and reflections on AG coaches' training programs, especially in the structure of the body of knowledge that provides a good basis for dealing with their daily challenges.

Keywords: *artistic gymnastics, professional development, coaching knowledge, professional practice*

INTRODUCTION

Artistic Gymnastics (GA) aims to bring together complexity and perfection in gymnasts' execution of movements (Costa, Marques, Oliveira, & Nunomura, 2020). The coach's role is even more complex, since she must also create a safe environment in which the teaching-learning process of new acrobatics takes place while it is inevitable that some manual help and closeness between the coach and the gymnast will occur (Barker-Ruchti & Tinning, 2010). In their studies, Côté, Salmela, Trudel, Baria, & Russell (1995) and Dowdell (2010) were the first to focus on AG coaches and provide an insight into the complexity of performance in this sport. Subsequently, several other studies have advanced this theme by investigating, for example, the intervention of AG coaches through the relationships established with the athletes (Costa et al., 2020; Oliveira, Bortoleto, & Nunomura, 2017); the coaches' level of knowledge about the motivational factors of athletes (Nunomura, Okade, & Carrara, 2012), and the knowledge required for teaching

gymnastics skills (Irwin, Hanton, & Kerwin, 2005). However, considering that the demands coaches face are directly related to the context in which they work (ICCE, 2013) and that most studies on AG focus on expert coaches who work at the most competitive levels (Côté et al., 1995; Irwin et al., 2005; Nunomura et al., 2012), there is a lack of studies looking at coaches at the beginning of their careers or working with athletes from less competitive categories.

In recent years, the model proposed by Côté & Gilbert (2009) has been used to define quality performance of sports coaches and the types of knowledge required to support it. This model indicates that coaches must master three groups of skills: (1) professional knowledge (comprising the specific contents of sports science and the processes that are part of the sport in which the coach works, such as knowledge about its technical-tactical aspects, physical preparation, training methodology, etc.); (2) interpersonal skills (including, for example, knowledge about people management, leadership and communication needed to establish relationships with various stakeholders in the sports context, such as athletes, parents, judges and other coaches), and (3) intrapersonal skills (including coaches' ability to reflect on, self-evaluate and think about their own behavior and professional performance).

When we think about the current AG situation, the training process has gained visibility in recent years because of the criticism and scandals related to sexual abuse and harassment reported in several countries (Novkov, 2019; Pinheiro, Pimenta, Resende, & Malcolm, 2014). This may be the result of unreasonable appreciation of coaches' for their professional knowledge due to AG's characteristic pursuit of perfection for competitive success (Costa et al., 2020). For Bortoleto & Schiavon (2016), advancement of scientific investigations may be one of the ways to minimize excessive striving for competitive results by gymnasts and moderate the authority of coaches while promoting more appropriate behaviors and a healthier sport environment. Given the emergence of this topic, this study can contribute to a broader understanding of coaches' early career and lead to reflections for the future work in AG. Thus, in this study, we aimed to identify the perceptions of coaches at the beginning of their careers regarding the types of knowledge required in their professional work.

METHODS

This is a descriptive study with a qualitative approach in which the focus is on the subjectivity of the experiences reported by the participants. We adopted the epistemological and ontological dimensions of the constructivist investigative paradigm, as we consider the relativity of the nature of knowledge and its construction from the interaction between the unique realities experienced by the participants (Denzin & Lincoln, 2018). With regard to the axiological dimension, the direct involvement and influence of researchers in the data collection and analysis process through their idiosyncratic experiences with the subject of the study is highlighted (Denzin & Lincoln, 2018). In this case, the researchers are part of the social reality studied and, therefore, do not separate themselves from the theme in order to present different perspectives on the subject (Rehman & Alharthi, 2016). This research was approved by the Human Research Ethics Committee of the Federal University of Santa Catarina under Opinion No. 4.079.059.

AG coaches from Santa Catarina (Brazil) participated in the research. The criteria adopted for the selection of participants were as follows: (1) affiliation to the Santa Catarina Gymnastics Federation (Brazil); (2) a maximum of 10 years of tertiary studies in Physical

Education[1], and (3) less than 10 years of professional experience in the sport. We chose these criteria to define a group of participants at the beginning of their careers, unlike other studies, such as those by Côté et al. (1995) and Irwin et al. (2005), which selected coaches with at least 10 years of practice, and Nunomura et al., (2012), in which the participants had on average 12.2 (among women) and 14.5 (among men) years of experience as a coach. The description of the participants is presented in Table 1, using pseudonyms to ensure anonymity.

Table 1.
Coaches' profile

	Age (years)	Gender	EG	EC	PTT	Discipline	Competitive level	Judge
			(years)					
Ella	25	F	11	6	4	WAG	State	State WAG
Sarah	24	F	13	6	3	WAG	State	-
John	31	M	10	7	9	WAG	State	-
Beth	23	F	8	5	2	WAG	State	-
Peter	26	M	6	5	5	MAG	State	State MAG
Average	25.8	-	9.6	5.8	4.6	-	-	-

Legend: C = Coach; F = Female; M = Male; EG = Experience as a Gymnast; EC = Experience as a Coach; PTT = Professional Training Time; WAG = Women's Artistic Gymnastics; MAG = Men's Artistic Gymnastics

We emphasize that the coaches participating in the research train athletes for state-level competitions. The state of Santa Catarina is not among the states with the greatest representation on the national level. The coaches work with all age groups, from children to adults, except Sarah who only trains in the children's category.

Initially, the participants answered a brief sociodemographic questionnaire prepared by the authors. In the next phase, the first author conducted semi-structured interviews with the aid of an online audio and video platform. Although the script was developed from Côté and Gilbert's (2009) study, we sought to elaborate general questions about daily requirements, (instead of influencing the participants to name the requirements with references to professional, interpersonal, and intrapersonal skills). Examples of such questions are: "How is your routine structured?"; "When you enter the gym, what are your first actions?" and "Could you describe what your training session is like?" The interviews lasted 62.6 ± 7.65 minutes on average. The data were transcribed verbatim with the help of the Microsoft Word software, totaling 47 pages with Arial font, size 12, single spacing, and two-centimeter margins. Due to the ontological characteristics of the paradigm adopted in the study, where subjectivity is also present in the researchers' interpretation of the coaches' reports, we chose to use the

[1] Due to the professionalization of sports coaches in Brazil, a university degree in Physical Education is required.

reflexive thematic analysis technique (Braun & Clarke, 2019). In this analysis procedure, the researcher is responsible for identifying, analyzing and reporting patterns found in the data using the six stages described by Braun e Clarke (2006) as a guide. Initially, the first author transcribed, read, and reread the interviews. Using an inductive approach, the analytical process proceeded with initial codes, generated to identify relevant points of interest based on the study aims. During this step, using Microsoft Word, the most relevant statements were grouped into codes. Next, we conducted a search for common topics among the initial codes, generating broader themes. In the fourth and fifth stages, respectively, the initial codes were revised within the themes to ensure the representativeness of the broader categories and to facilitate their naming. The last stage resulted in the analysis report presented in the results section.

It is noteworthy that the first author led the analysis, and the second author played the role of a "critical friend" during all stages. In addition, because of the coauthors' expertise in coaches' performance and qualitative research, frequent meetings were held to discuss the analytical process. These actions were intended to provide the first author with critical reflections on the analyzed data (Smith & McGannon, 2018). Thus, the authors identified three themes and ten sub-themes.

RESULTS

Applying sports science to professional practice

Planning development and adaptation

When planning, coaches need to consider the time of the year to define the content of the training process. As Beth points out, planning goes through major modifications in a pre-competitive or competitive period: "Outside of competition periods, we focus on physical preparation; separate elements. When we are close to the competition period, we practice sequences; so, it changes a lot". Furthermore, it seems necessary to integrate the aspects of physical conditioning with technical development to optimize the gymnast's training time: "I have to mix the strength part with the gymnastic moves part, because otherwise I don't have time to train" (Sarah). Planning adaptation is also a constant process in coach's work. John reports that changes to his initial plan are sometimes necessary even to maintain the gymnast's physical integrity: "If you know she got hurt in the previous training, you ask if she is okay, if she can do it, or if she is still in pain. If she says she is in pain, you must check what you had planned for her and change it".

Understanding gymnasts' personality

Understanding athletes' personality is perceived as a coach's duty and seems to be related to the long-term development process. Beth believes that her work must meet the physical needs of her athletes to facilitate their sports development: "Understand the biotype of the children, understand the difficulties they have, and work to improve". Moreover, understanding of gymnasts' personality also includes gymnasts' mental state. Ella comments that there is a need to expand the biological look to include psychological variables that are present beyond the training routine: "In competition, much more than in training, we have the psychological part, the emotional part, the parents in the bleachers, their [gymnasts] nervousness, being too hard on themselves, which we end up finding out only during the competition".

Building the teaching-learning process

All the coaches highlighted the need to master the AG-specific knowledge as a prerequisite for working in the sport. Beth addresses the importance of knowing the correct execution of gymnastic elements: "I think that, first of all, she [the coach] has to

know the technique of artistic gymnastics, because it's no use being a good teacher if you don't know the sport. The technique involves exercises, moves, their execution". Ella adds that, by knowing each gymnastics element, the coach must develop teaching-learning processes and use manual aids with the athletes so that they can safely perform new moves: "So, we take a skill, we divide it into several types of educational activities and, generally, in these educational activities, we use a lot of aids to correct the movement, and then the athlete can perform the whole move with an appropriate technical design". In this teaching-learning process, Peter also highlights different ways to ensure the safety of gymnasts, especially with the use of manual aids and mats:

"I guess I always surround myself with every possible security measure. I grab a gymnast, because if he falls, I can lessen the weight on the arms and prevent a fall on the neck. I try to get him as close to the mat as possible. I use a lot of mats."

Figure 1 presents the themes and sub-themes concerning the requirements mentioned by the AG coaches.

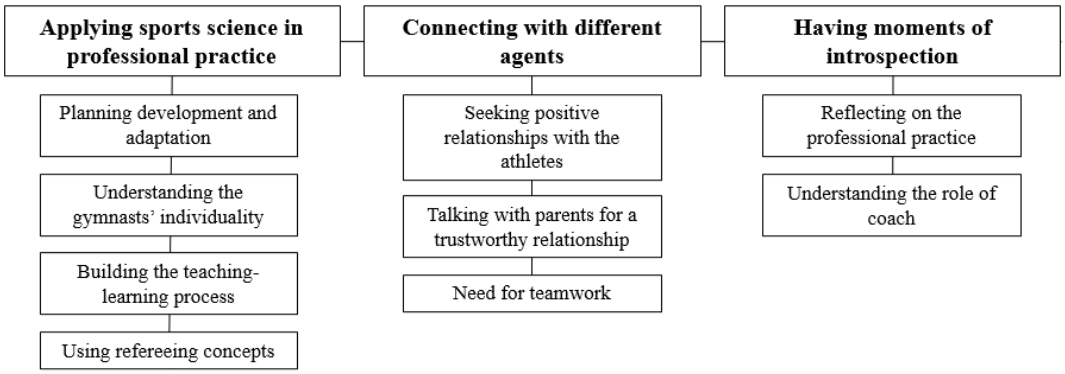

Figure 1. Requirements for coaches' professional practice

Using judging concepts

As part of requirements to work as a coach, the use of judging concepts is also considered an indispensable skill in the training routine and in competitions, from setting up gymnasts' presentation sequences to their final performance: "You don't necessarily need to be a judge, but you have to understand when there will be a deduction or not. It is part of the rules of the sport." (Sarah). Although Sarah highlights that being a coach does not imply being a judge, John confirms that judging knowledge is present in the construction of gymnasts' sequences and in competitions where the coach needs to check the score obtained:

"The coach has to put together a sequence and see if the child meets the requirements of the apparatus, see if he/she has a connection between the elements and check the Code for the grade of difficulty [...]. Thus, in a competition, if the grade is too different, you can question it."

Connecting with different stakeholders

Seeking positive relationships with athletes

Building positive relationships with athletes is seen as a necessary effort, especially given the cases of abuse that have occurred in high performance AG in recent years[2]: *"The approaches nowadays have to be much more attentive, we need to be*

[2] Distinct forms of abuse (physical, sexual and emotional) in the context of artistic gymnastics have gained visibility in recent years in several countries such as Brazil (Globo Esporte, 2019), the United States (Washington Post, 2015), Japan (Japan Times, 2018), Australia (Fox Sports, 2021), among others.

mindful of the athletes, of the feedback" (Ella). Such care is perceived as indispensable to strengthen the relationship between the coach and the athlete and contribute to athletes' long-term engagement in AG. Sarah believes that effective communication and understanding of how gymnasts feel about their training routine should be a set of interpersonal skills that every coach possesses: *"This communication with athletes needs to exist as well. Knowing if an athlete is happy performing a move*" (Sarah).

Talking with parents for a trustworthy relationship

Parents' participation in athletes' trajectory is a recurring theme in the statements of all coaches. However, this task can be even more challenging than the training sessions themselves: *"It's much harder to manage the part with parents than the training itself"* (Ella). Due to this, the coaches clarify that constant communication with parents is the key to establishing a trusting relationship:

"I always talk to the parents. And in the same way as I am talking to you now, I always discuss everything with them. Because, I think, for the parents, they are leaving their child, so precious to them, in my hands. I want to always assure them that they are leaving them in the hands of someone who cares about them."

As coach John points out, it is important, through this communication, to make parents understand the specifics of the sport and the presence of manual aids in teaching the moves, so that they know how to differentiate the physical contact necessary for safety in gymnastics from what could be sexual abuse or aggression: "*You apply some pressure, you push, you squeeze, and sometimes you end up leaving a bruise because you use some strength. But it is not like you are hitting or caressing. So, all of that needs to be explained to the parents. I will have to touch her. It is a professional physical contact*".

The need for teamwork

Coaches working with different professionals in AG is common considering the complexity of athlete's development. Our coaches report working with assistant coaches, ballet professionals, and psychologists. According to Peter, this multidisciplinary intervention helps the coach delegate different jobs: "*For me, having a team to share tasks with is fantastic, especially the team I have today. I had other colleagues before who were not that professional; that didn't work out. I ended up doing most jobs.*"

Teamwork is also important since younger coaches can learn from those who have been working in the gym longer, as coach Beth says: *"I plan a lessons and Max [head coach] helps, corrects and shows what works best. For me, it is very important, because he has been working longer and I am just starting"*. Moreover, the relationship with more experienced coaches is fundamental for younger coaches' professional development, as John highlights: *"When difficulties arise, I try to reflect on the moment and also talk to the people who work with me. How would they deal with this situation? What would be the best way? Sometimes, what they would do is not what I did, so I think: 'I should have done that'"*.

Having moments of introspection

Reflecting on the professional practice

Reflecting during practice itself is an action present in the coach's work, whether through the process of self-knowledge or the evaluation of the effectiveness of the teaching-learning process. Ella explains that she uses training courses as moments to reflect on her own practice, even if the course is not related to AG: *"It is a self-knowledge course, where I can look at myself and reflect on how I can use my approaches, words, and temperament in my work, especially with a training team"*.

Still on the reflexive process, John tells us about the importance of seeking to

recognize, through an analytical process, what is behind gymnasts' difficulties and what is his own role in this process:

"Sometimes you can't assign an element and you think: "Am I the problem? Could the problem be the instructions? Or is the problem that the child doesn't want to do it?". If the child doesn't understand, then the problem is in me, because I didn't get it across to him/her, or in the instructions that I gave him/her and he/she didn't understand.

Understanding the role of coach

The fact that coaches work, in some cases, in both the initiation phase and in the specialization and performance phases, causes them to need to recognize precisely what their role as a coach is for different groups of gymnasts, generating adaptations in behaviour and communication: *"I have to separate this, my school teacher version that I need to loosen, and my training teacher version. It's a little difficult, but there's not much I can do"* (Sarah). Still reflecting on the role that should be played, John reflects on his own performance, thinking about what is required and his own weaknesses: *"As a professional I need to be patient, something I am not, but I'm doing my best to improve this [laughs]. I need to be a person who encourages and motivates the child. Who doesn't deceive him/her but is realistic with him/her. Who shows the reality, without deceiving the child"*.

DISCUSSION

This is to identify the perceptions coaches have at the beginning of their careers regarding the types of knowledge required to perform in their professional capacity. The participants of the study described their performance routines in AG and, in this way, it was possible to observe different types of skills, such as those proposed by Côté and Gilbert (2009). According to Quinaud, Backes, Nascimento Junior, Carvalho, & Milistetd (2020), it is common for sports coaches to attribute greater importance to professional and interpersonal knowledge, since it is more noticeable in the coach's daily practice and in the relationships established. In contrast, intrapersonal knowledge is not consciously present in coaches' routines and, therefore, tends to be less valued (Côté & Gilbert, 2009; Quinaud et al., 2020). Furthermore, the valorization of professional knowledge may be related to the coach training process. According to Bortoleto & Schiavon (2016), in Brazil, the paths taken by AG coaches continue to include passing knowledge from one generation to another; acquiring it through previous experience as a gymnast, and the replication of methodologies that previously generated good results. Milistetd, Trudel, Mesquita, & Nascimento (2014) e Tozetto, Galatti, Scaglia, Duarte, & Milistetd (2017) indicate that there is a gap in the training context of Brazilian sports in general, lacking, above all, systematized opportunities for coaches to learn to reflect on their own practices.

Professional knowledge, understanding gymnasts' personalities, building up teaching skills and using judging knowledge are all requirements for coach's performance. The findings indicate, above all, the importance of mastery of the specifics of AG. This concern seems to also apply to expert coaches, as identified by Irwin et al. (2005), when noticing the need for a high level of technical knowledge and the ability to organize this knowledge to develop effective progressions and sequence them appropriately. This fact may be related to the AG culture, in which the teaching-learning process is historically more coach-centered and, therefore, the coach is fully responsible for decisions about the conduct of training sessions (Irwin et al., 2005; Oliveira et al., 2017) in order to combine the complexity of exercises with gymnasts' execution precision (Costa et al., 2020). In addition, by promoting the technical development of athletes, coaches recognize the risks gymnasts are exposed to when performing more complex skills. Therefore, technical knowledge is a necessity for a coach in

order to pay attention to gymnasts' safety, both physical and mental (Araújo, 2012).

We identified some requirements for coaches so that they can establish connections with other stakeholders involved in the AG environment that are grounded in interpersonal skills. Coaches apparently seek to build positive relationships through communication and by getting feedback from their athletes. These strategies represents a small advance from the previous situation of predominant domination and authoritarianism in the relationships between coaches and gymnasts (Barker-Ruchti & Tinning, 2010; Costa et al., 2020; Oliveira et al., 2017). In contrast, our coaches mention the need to gain the parents' trust, citing the importance of explaining that situations such as "squeezing or pushing gymnasts" are necessary and commonplace when using gymnastics teaching aids. Their intention to develop good relationships with parents seems indispensable, since parents' opinions about coaches or their teaching methods can also influence the relationship between the coach and the athlete (Jowett & Timson-Katchis, 2005; Schiavon & Soares, 2016). However, as Pinheiro et al. (2014) already found, in the context of AG, parents tend to place considerable trust in coaches and consequently there is still some residual concerns that negative and historically normalized practices in the relationship between coaches and gymnasts may still be reproduced and veiled by younger coaches as well since athletes in this sport have great confidence in their coaches and will execute moves in the way they were taught (Barker-Ruchti & Tinning, 2010).

Two other subthemes pointed out the need for the mastery of intrapersonal skills in the coaches' practice. The data indicate that there is a presence of reflective processes during interventions. For Gallimore, Gilbert, & Nater (2014, p. 126), reflection involves "pondering, reviewing and questioning of their experiences that prompts individuals to adapt and change their behaviours in subsequent action". The potential of the reflective process to break through the AG culture seems limited, since the reflections generated by the study participants are almost always related to the coach's own concerns about the effectiveness of the teaching-learning process. In fact, the theoretical framework proposed by Irwin et al. (2005) points out that during the development of gymnastics skills, coaches record experiences and, through them, when teaching new skills, they reflect and design strategies and educational processes that may prevent future problems. Finally, the results also highlight the process by which a coach understands her role within the context in which she works. Due to this diversity of roles and contexts, acting according to the specifics of each situation is essential to ensure success in coach's activities (ICCE, 2013). Thus, identifying the specifics of the context and understanding the implications of their performance are also important for coaches to develop.

CONCLUSION

The results of this study help us understand that coaches' work in the beginning of their careers in the sport is based on a wide range of skills, mostly related to the specifics of AG. Unlike in other studies, we noticed the coaches' intention to build a positive environment for their gymnasts; however, this does not mean that this has been successfully applied in practice. Similarly, the coaches highlight the need to establish a relationship with parents, although in some cases this means seeking approval for certain behaviors that a coach can continue to display. Furthermore, it should be noted that the manifestation of intrapersonal skills that is largely focused on meeting the performance needs of gymnasts weakens the possibility of developing a new culture in AG that starts with coaches' practice.

Overall, the findings of this study have implications for reflecting on the need for AG coaches' training programs to

understand the complexity and challenges new coaches' face, as well as the culture established in the sport. Thus, by aligning training and practice, it is possible to contribute to a safer and more positive environment in the sports.

This study's aim was solely to understand how new coaches perceived their work through their own accounts by conducting interviews with them. It is important to combine observation instruments with this type of data collection to be able to visualize whether, in practice, what is expressed by coaches actually takes place. Furthermore, we understand the limitations inherent in trying to identify requirements that are not always consciously expressed in coaches' work, but rather in moments of introspection and self-evaluation that make up the intrapersonal skills framework.

REFERENCES

Araújo, C. (2012). *Manual de ajudas em Ginástica*. Jundiaí (São Paulo): Editora Fontoura.

Barker-Ruchti, N., & Tinning, R. (2010). Foucault in leotards: Corporeal discipline in women's artistic gymnastics. *Sociology of Sport Journal*, *27*(3), 229–250. https://doi.org/10.1123/ssj.27.3.229

Bennie, A., & O'Connor, D. (2010). Coaching philosophies: Perceptions from professional cricket, rugby league and rugby union players and coaches in Australia. *International Journal of Sports Science and Coaching*, *5*(2), 309–320. https://doi.org/10.1260/1747-9541.5.2.309

Bortoleto, M. A. C., & Schiavon, L. M. (2016). Artistic gymnastics - why do coaches resist change? *Sports Coaching Review*, *5*(2), 198–201. https://doi.org/10.1080/21640629.2016.1201360

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Braun, V., & Clarke, V. (2019). Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health*, *11*(4), 589–597. https://doi.org/10.1080/2159676X.2019.1628806

Costa, V. R., Marques, R. F. R., Oliveira, M. dos S., & Nunomura, M. (2020). "Puppets" in women's artistic gymnastics: the coach-gymnast relationship from Pierre Bourdieu's lens. *Science of Gymnastics Journal*, *12*(3), 367–380.

Côté, J., & Gilbert, W. (2009). An Integrative Definition of Coaching Effectiveness and Expertise. *International Journal of Sports Science & Coaching*, *4*(3), 307–323. https://doi.org/10.1260/174795409789623892

Côté, J., Salmela, J., Trudel, P., Baria, A., & Russell, S. (1995). The Coaching Model: A Grounded Assessment of Expert Gymnastic Coaches' Knowledge. *Journal of Sport and Exercise Psychology*, *17*(1), 1–17. https://doi.org/10.1123/jsep.17.1.1

Dowdell, T. (2010). Characteristics of effective gymnastics coaching. *Science of Gymnastics Journal*, *1*(2), 15–23.

Fox Sports (2021). Bombshell report into Australian gymnastics exposes decades of horrifying abuse. Available from https://www.foxsports.com.au/olympics/gymnastics-gymnastics-australia-news-report-into-abuse-sexual-abuse-australian-human-rights-commission/news-story/7584cd3cdab1c44e441bceecc35aa43a (Febrary 10, 2020)

Gallimore, R., Gilbert, W., & Nater, S. (2014). Reflective practice and ongoing learning: A coach's 10-year journey. *Reflective Practice*, *15*(2), 268–288. https://doi.org/10.1080/14623943.2013.868790

Globo Esporte. (2019). Acusado de abuso, técnico Fernando de Carvalho Lopes é banido da Ginástica por tribunal. Available from https://ge.globo.com/ginastica-artistica/abuso-na-

ginastica/noticia/acusado-de-abuso-tecnico-fernando-de-carvalho-lopes-e-banido-da-ginastica-por-tribunal.ghtml (Febrary 10, 2020)

ICCE. (2013). International Sports Coaching Framework. Version 1.2. Human Kinetics.

http://www.icce.ws/_assets/files/iscf-1.2-10-7-15.pdf

Irwin, G., Hanton, S., & Kerwin, D. G. (2005). The conceptual process of skill progression development in artistic gymnastics. *Journal of Sports Sciences*, *23*(10), 1089–1099. https://doi.org/10.1080/02640410500130763

Japan Times. (2018). Miyakawa speaks out, calls for lifting of her coach's ban. Available from https://www.japantimes.co.jp/sports/2018/08/30/more-sports/gymnastics/miyakawa-speaks-calls-lifting-coachs-ban/ (Febrary 10, 2020)

Jowett, S., & Timson-Katchis, M. (2005). Social networks in sport: Parental influence on the coach-athlete relationship. *Sport Psychologist*, *19*(3), 267–287. https://doi.org/10.1123/tsp.19.3.267

Milistetd, M., Trudel, P., Mesquita, I. M. R., & Nascimento, J. V. (2014). Coaching and Coach Education in Brazil. *International Sport Coaching Journal*, *1*(3), 165–172. https://doi.org/10.1123/iscj.2017-0088

Novkov, J. (2019). Law, Policy, and Sexual Abuse in the #MeToo Movement: USA Gymnastics and the Agency of Minor Athletes. *Journal of Women, Politics and Policy*, *40*(1), 42–74. https://doi.org/10.1080/1554477X.2019.1563412

Nunomura, M., Okade, Y., & Carrara, P. (2012). How much artistic gymnastics coaches know about their gymnasts' motivation. *Science of Gymnastics Journal*, *4*(2).

Oliveira, M. S., Bortoleto, M. A. C., & Nunomura, M. (2017). A relação técnico-atleta na ginástica artística feminina. *Revista Brasileira de Educação Física e Esporte*, *31*(3), 639–650. https://doi.org/10.11606/1807-5509201700030639

Pinheiro, M. C., Pimenta, N., Resende, R., & Malcolm, D. (2014). Gymnastics and child abuse: an analysis of former international Portuguese female artistic gymnasts. *Sport, Education and Society*, *19*(4), 435–450. https://doi.org/10.1080/13573322.2012.679730

Quinaud, R. T., Backes, A. F., Nascimento Junior, J. R. A. do, Carvalho, H. M., & Milistetd, M. (2020). Development and validation of the coach knowledge questionnaire: measuring coaches' professional, interpersonal and intrapersonal knowledge. *International Journal of Sport and Exercise Psychology*, *0*(0), 1–17. https://doi.org/10.1080/1612197X.2020.1801795

Rehman, A. A., & Alharthi, K. (2016). An introduction to research paradigms in distance education. *International Journal of Educational Investigations*, *3*(8), 51–59.

Schiavon, L. M., & Soares, D. B. (2016). Parental support in sports development of gymnasts. *Rev Bras Educ Fís Esporte*, *30*(1), 109–118.

Smith, B., & McGannon, K. R. (2018). Developing rigor in qualitative research: problems and opportunities within sport and exercise psychology. *International Review of Sport and Exercise Psychology*, *11*(1), 101–121. https://doi.org/10.1080/1750984X.2017.1317357

Tozetto, A. V. B., Galatti, L. R., Scaglia, A. J., Duarte, T., & Milistetd, M. (2017). Football coaches' development in Brazil: a focus on the content of learning. *Motriz: Revista de Educação Física*, *23*(3), 1–9. https://doi.org/10.1590/s1980-6574201700030017

Washington Post (2015). Top U.S. gymnastics coach Marvin Sharp arrested on suspicion of child molestation. Available from https://www.washingtonpost.com/news/ear

ly-lead/wp/2015/08/25/top-u-s-gymnastics-coach-marvin-sharp-arrested-on-suspicion-of-child-molestation/ (Febrary 10, 2020)

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Article received: 29.11.2022
Article accepted: 31.1.2023

THE INSTITUTIONAL ORGANIZATION OF NATIONAL GYMNASTICS FEDERATIONS AND THE OFFER OF COACH EDUCATION PROGRAMS FOR GYMNASTICS FOR ALL: AN INTERNATIONAL ANALYSIS

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Original article *DOI:15.1.133-143*

Abstract

Coach education programs by National Gymnastics Federations (NGF) can provide in-depth and specific discussions and contribute to the development of gymnastics in different countries, as they address the specific interests and the people involved with it. For these actions to take place, a certain level of organization of the institutions is required and the existence of specific committees or commissions can contribute to this process since they possess the knowledge of the area and are familiar with organization of relevant actions. This study aims to explore the provisionof coach education programs for Gymnastics for All (GFA) and the organization of NGF worldwide. In total, 44 NGFs were consulted about the existence of such committees or commissions and the promotion of coach education programs for GFA and other gymnastics modalities. We used an online questionnaire hosted on the Google Forms® platform, in four languages. The answers were processed by simple statistics and analyzed according to the research context. The responses obtained show that 36 NGFs have Technical and GFA Committees in their organization, while eight do not have such bodies (smaller institutions and still poorly structured). 30 NGFs claimed to have GFA Committees, a meaningful number. Additionally, 30 NGFs conduct coach education programs for GFA. The analysis of the data showed that there is a correspondence between the existence of Technical Committees and GFA Committees and organisation and promotion of coach education programs.

Keywords: *professional education; committee; National Gymnastics Federations*

INTRODUCTION

The initial education and subsequent continuing coach education are considered essential for maintaining and improving the quality of sports development and body practices (Cushion, Armor & Jones, 2003). In an attempt to support this educational process, coach education systems worldwide are in a constant process of renewal and reconstruction (Mallett, Trudel, Lyle & Rynne, 2009).

Coach education can guarantee the quality of professional development (International Council for Coaching Excellence [ICCE], 2013). Although it is not possible to control people's experiences throughout their lives, institutionalized learning opportunities can be significantly important in promoting social relationships that support effective learning processes and result in conscious co-constructions

about the role of teaching sports and body practices.

Legislations of different countries define and regulate the role of each institution in this education. In some locations, mandatory university-level education in Physical Education or Sports ensures the central role for universities. However, in other countries, volunteers, part-time paid professionals or full-time paid professionals can act as coaches (ICCE, 2013); this increases the offerings provided by other institutions, such as national sports federations. A mix of these two coach education systems is also observed.

Coach education is a responsibility of national sports federations; in a political context they aim to increase the modernization and professionalism in this field (Piggott, 2012) or mediate the relationships between managers and coaches (Jones & Thomas, 2015; Vygotsky, 1997). Their importance will or will not be taken into account, depending on how each program is developed; nevertheless, it is in the interest of studies assessing coach education, in our case, in gymnastics and GFA, to learn more about the current situation of such programs.

Considering the above, this study had three objectives: to learn more about the requirements of each country participating in the research and assess the mandatory education to work in gymnastics and GFA; to investigate the organization of NGFs and the existence of Technical Committees, and to recognize NGFs that offer coach education programs. Also, this study provides reflections on these findings in an attempt to correlate data obtained in the analysis.

METHODS

This is an applied qualitative study using an exploratory and descriptive approach (Lakatos & Marconi, 2003; Triviños, 1987), in which a comprehensive analysis was conducted with a complete collection (Flick, 2009).

All NGF members of the International Gymnastics Federation (FIG - *Fédération Internationale de Gymnastique*) in January 2016 and NGFs included in the Continental Unions were invited to participate in this study, totaling 136 NGFs. After formal invitations made in four languages (Portuguese, Spanish, French and English) by email and/or through the official social media page of each institution, 44 answers were received. The only inclusion criterion in this study was that the institution had to be an NGF representing a country, a nation, or an administrative group.

The study participants included: 8 countries in Africa (South Africa, Algeria, Benin, Cape Verde, Libya, Mauritius, Mozambique, and Namibia), 10 countries in the Americas (Argentina, Aruba, Barbados, Brazil, Canada, the United States, the Cayman Islands, Paraguay, Trinidad and Tobago, and Venezuela), 6 countries in Asia (Bangladesh, Qatar, Singapore, Hong Kong, Republic of Korea, and Mongolia), 19 countries/locations in Europe (Germany, Andorra, Austria, Azerbaijan, Denmark, Slovakia, Estonia, Finland, Gran Canaria, Great Britain, Ireland, Iceland, Italy, Kosovo, Luxembourg, Monaco, Norway, Portugal, and Sweden), and one country in Oceania (Australia).

This study used one instrument, i.e., a standardized questionnaire, with open- and closed-ended questions. The questionnaire was available in the four languages mentioned above. The questionnaire was distributed to NGFs in two ways: using the Google Forms® platform, preferably, and in a Word® file, for NGFs that requested it.

This study analyzed the following issues:

a) requirements of each locality/country regarding mandatory education to work in gymnastics and GFA:
   - "Does the Gymnastics Federation you are associated with require higher education course to work as a gymnastics coach/teacher (all disciplines)? If yes, what kind of higher education course is

required? Is this a federation's requirement or a national law for all sports?"
- "Does the Gymnastics Federation you are associated with require any specific training in gymnastics to work as a gymnastics coach/teacher (all disciplines)? If so, what kind of training is required?"

b) organization of NGFs, considering the existence of Technical Committees:
- "Does the Gymnastics Federation you represent have Technical Committees for specific disciplines? If so, which disciplines have a specific Technical Committee?"

c) provision of coach education programs by the institution:
- "Does the Gymnastics Federation you are associated with offer coach/teacher education programs? If so, for which disciplines and practices?"

Data from this stage were analyzed using simple descriptive statistics. This analysis allowed an exploratory analysis of data, ensuring a numerical form to qualitative characteristics (Lakatos & Marconi, 2003).

This research project was submitted to and approved by the Research Ethics Committee of Faculdade de Ciências Médicas da Unicamp, with registration on Plataforma Brasil and Certificate of Submission for Ethical Assessment (CAAE) nº 1.400.398.

RESULTS

Questioning the NGFs about higher education courses required to work in gymnastics resulted in the answers shown in Table 1.

Among the types of higher education required, the following were mentioned: a degree in Physical Education and Sports by 3 NGFs (Bangladesh, Benin, and Brazil); a degree in Physical Education complemented by NGF courses required by one NGF (Paraguay); higher education – not a specific course – required by four NGFs (Azerbaijan, Qatar, Mongolia, and the Republic of Korea); higher education in the field of gymnastics by 2 NGFs (Algeria and Kosovo), and NGF or FIG programs by 5 NGFs (Andorra, Argentina, Gran Canaria, Luxembourg, and Monaco).

In addition, we asked if this is a specific rule of the NFG or a national law for all sports. Of 15 countries/localities that require higher education, 9 (60%) reported it was a national regulation for all sports and body practices (Algeria, Andorra, Azerbaijan, Brazil, Republic of Korea, Kosovo, Monaco, and Mongolia) and the other 6 (40%) (Argentina, Bangladesh, Benin, Qatar, Gran Canaria, Luxembourg, and Paraguay) reported it was a specific rule of the NGF.

We asked the NGFs about specific technical education in gymnastics: 30 out of 44 NGFs (68.1%) answered they required specific education in gymnastics (South Africa, Germany, Algeria, Andorra, Argentina, Aruba, Australia, Austria, Bangladesh, Barbados, Benin, Canada, Qatar, Singapore, Slovakia, Estonia, Gran Canaria, Great Britain, Hong Kong, Ireland, Iceland, Libya, Luxembourg, Mauritius, Monaco, Mongolia, Paraguay, Portugal, Trinidad and Tobago, and Venezuela) and 14 (31.9%) did not require it.

Regarding the type of specific education in gymnastics required by NGFs, we received the following answers (Table 2). Other responses included: Barbados requires the FIG Academy course; Canada requires that all coaches complete a training with the Canadian Gymnastics Federation called Gymnastics Canada; Ireland requires certification in discipline-specific coach courses that contain pedagogical content, and Portugal requires, according to the country's legislation – Law Nº 40/2012, coach education courses offered by the Portuguese Gymnastics Federation or an equivalent higher education course.

Table 1
Requirements of higher education courses to work in gymnastics

Answer	Number of countries (%)	Countries
Require higher education courses	15 (34%)	Algeria, Andorra, Argentina, Azerbaijan, Bangladesh, Benin, Brazil, Qatar, Gran Canaria, Kosovo, Luxembourg, Monaco, Mongolia, Paraguay, and the Republic of Korea
Higher education courses not required	29 (66%)	Aruba, Australia, Austria, Barbados, Canada, Cape Verde, Cayman Islands, Denmark, Estonia, Finland, Germany, Great Britain, Hong Kong, Iceland, Ireland, Italy, Libya, Mauritius, Mozambique, Namibia, Norway, Portugal, Singapore, Slovakia, South Africa, Sweden, Trinidad y Tobago, United States, and Venezuela

Table 2
Type of specific education requirements

Answer	Number of countries (%)	Countries
Technical-pedagogical courses	19 (63.3%)	Algeria, Andorra, Argentina, Australia, Austria, Estonia, Germany, Gran Canaria, Great Britain, Hong Kong, Iceland, Libya, Luxembourg, Mauritius, Singapore, Slovakia, South Africa, Trinidad and Tobago, and Venezuela
Academic courses	7 (23.3%)	Aruba, Bangladesh, Benin, Qatar, Monaco, Mongolia, and Paraguay
Other types of education	4 (13.3%)	Barbados, Canada, Ireland, and Portugal

Next, we asked the NGFs about their organization. As expected, most of them have at least one Technical Committee or GFA Committee in their organization, as detailed below

- 34 NGFs (77.2%) reported a Technical Committee for women's artistic gymnastics and a Technical Committee for men's artistic gymnastics;
- 32 NGFs (72.7%) reported a Technical Committee for rhythmic gymnastics;
- 30 NGFs (68.1%) reported a GFA Committee;
- 24 NGFs (54.5%) have a Technical Committee for aerobic gymnastics;
- 23 NGFs (52.2%) have a Technical Committee for trampoline gymnastics;
- 17 NGFs (38.6%) have a Technical Committee for acrobatic gymnastics;
- 6 NGFs (13.6%) have a TeamGym Technical Committee;
- 2 NGFs (4.5%) have a Technical Committee for rope skipping;
- 6 NGFs (13.6%) reported other committees: Technical Committee for aesthetic gymnastics (Finland); fitness and wellness (Italy); group training,

children's gymnastics and youth activities (Sweden); resources and research (Hong Kong).

Finally, we asked the NGFs if they provided education programs for gymnastics coaches. Seven (16%) of 44 NGFs do not offer coach education programs and 37 (84%) NGFs offer such programs (South Africa, Germany, Algeria, Andorra, Argentina, Australia, Austria, Bangladesh, Benin, Cape Verde, Canada, Qatar, Singapore, Denmark, Slovakia, the United States, Estonia, Finland, Great Britain, Hong Kong, Cayman Islands, Ireland, Iceland, Italy, Kosovo, Libya, Luxembourg, Mozambique, Mongolia, Namibia, Norway, Paraguay, Portugal, Republic of Korea, Sweden, Trinidad and Tobago, and Venezuela). The figure below shows the disciplines and practices covered by the education programs.

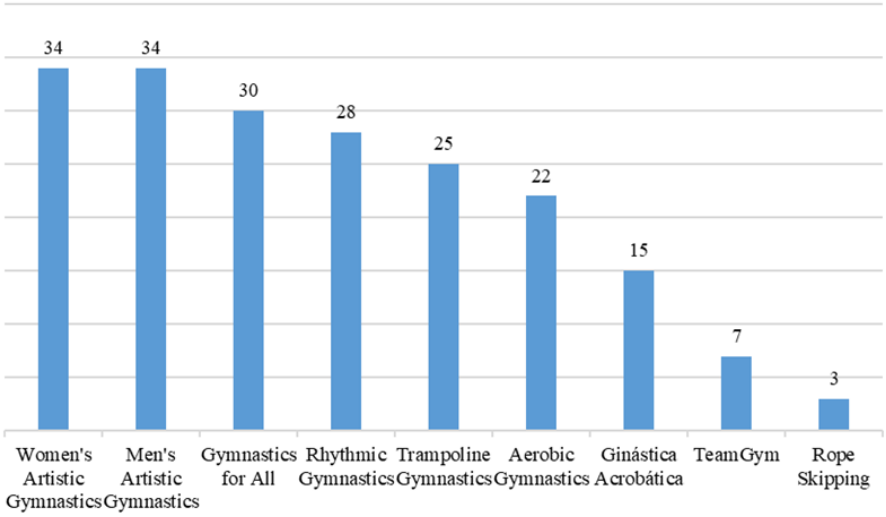

Figure 1. Presence of committees in the organization of NGFs.

Also, 4 NGFs claimed to provide education for other practices: aesthetic gymnastics (Finland), freestyle gymnastics, cheerleaders, gymnastics for preschool children and gymnastics for people with disabilities (Great Britain), various ball games, health and dance activities (Germany), and gymnastics for children and choreography (Sweden).

DISCUSSION

Only 8 NGFs reported they required a university course to work as a gymnastics coach, despite the academic literature recommending university education as the appropriate training for this occupation (Milistetd, 2015). Recent studies have contributed to the dissemination of pedagogical opportunities for coach education in universities (ICCE, 2013; Jones, Morgan & Harris, 2012; Milistetd, 2015; Morgan, Jones, Gilbourne & Llewellyn, 2013). However, problems are observed in this type of education, including the short time dedicated to the acquisition of knowledge required for coach-related activities, and the type of pedagogical strategies adopted (Milistetd, 2015; Morgan, Jones, Gilbourne & Llewellyn, 2013). Therefore, although universities are considered important potential coach training centers, further reflection and subsequent implementation of approaches to development and learning are required, so that the reality reflects the highlighted potentialities. Hence, the situation found in this study attributes even more importance to learning opportunities provided by NGFs.

The fact that university education is mandatory for gymnastics coaches in Brazil

indicates that federal organizations can influence the organization of content, pedagogical strategies, training hours, and other variables of university courses. Such influence, allowed by regulatory laws, can be positive if these organizations promote a more active and effective education for coaches. Among the important factors we emphasize the possibility that NGFs encourage social relationships between learners and themselves and responsible mediators so that the learning processes can be established in a meaningful way.

On the other hand, the fact that the mandatory university education in Physical Education and Sports is a norm among some NGFs leads to two conclusions: this initiative can either be an opportunity to shed the responsibility for offering training programs, or an interesting way of placing NGFs closer to university courses. If NGFs only require such training but do not monitor whether minimum knowledge for proper performance is provided to coaches, and if they still do not provide opportunities for continuing education, the situation of coach practice remains without in-depth reflections. Thus, we can consider that teaching sports and body practices will provide few opportunities for specific mediations regarding this subject in the university environment. Also, further discussions are still required about the responsibility of each of these institutions in coach education.

The results indicate that specific training in a sport or body practice is valued in relation to general, broader training. This information attributes to technical-pedagogical courses the importance of discussing not only specific aspects, but also other general topics that are essential for coaches' work. These topics include interpersonal knowledge; referring to the social context and established relationships, and intrapersonal knowledge, such as work philosophy (ICCE, 2013). These learning opportunities should favor more active social relationships that allow for the exchange of experiences between those involved in order to encourage co-construction of new knowledge and reflections required for sport development.

In addition, we highlight here the initiative to ensure equivalence between university courses and NGF programs indicated by the NGF from Portugal. This process considers the education obtained as the standard, regardless of the responsible institution, while allowing coaches who opt for general training in higher education to obtain the minimum level of specific education in gymnastics as traditionally offered by the NGF. Such equivalence favors apprentice coaches who want a more complete university education, as it facilitates the licensing for professional practice. It can be an interesting possibility, as it allows universities to offer specific education for each type of sport or body practice, facilitating the co-construction of knowledge.

Ten NGFs do not require any type of education to be a coach. Some of these NGFs may have an institutional structure that is not fully established, which can lead to fragile regularization of the coach profession and small number of institutional education opportunities in the countries. The respondent from the Cayman Islands reported: "I would also like you to note that we are a very small country/island and our federation is managed by a group of three volunteers with limited capacity."

On the other hand, the situation of some NGFs represents the gymnastics culture experienced in their countries, allowing institutions to believe that specific professional education is not necessary. This is the case of Scandinavian countries such as Denmark, Finland, Norway and Sweden. These countries are known for their culture of gymnastics practice, as they have promoted gymnastics since the 18th century (Patrício, Bortoleto & Carbinatto, 2016). In these countries, coaches are mostly volunteers. Unquestionably, the knowledge acquired through experience as a former gymnast contributes to the performance as a coach. At the same time,

we recognize the need for conscious reflection and co-construction of scientific concepts for such practice. These learning processes are provided by conscious mediations, which include institutional and informal opportunities. In addition, we highlight Piggott (2012), who considers the participation in institutional learning opportunities as 'rites of passage,' providing coaches with knowledge that ensures security and prestige in their role.

In general, data obtained in this study show the required educational levels for gymnastics coaches. However, based on this discussion, we can associate the provision of such programs with the regulatory guidelines for teaching sports and body practices and the organization of such NGFs. This way, we try to find any relation between promoting mediations that are developed through the existence of programs and the quality and specificity of such mediations, so that we can finally analyze how they take place

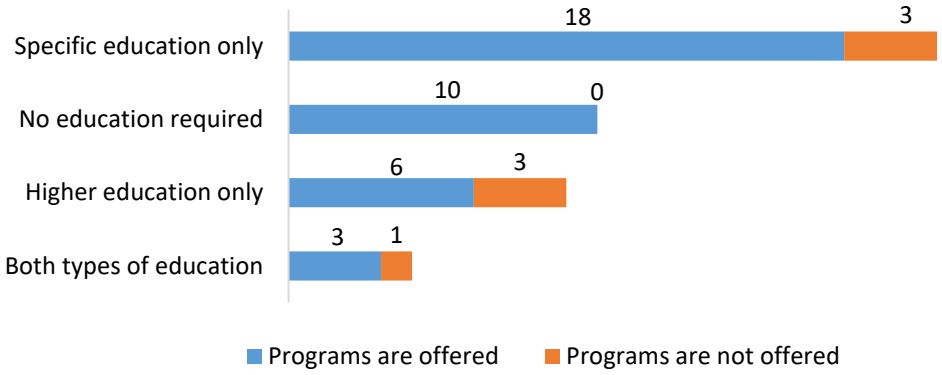

Figure 2. Relation between the education requirement to work as a gymnastics coach and the provision of coach education programs.

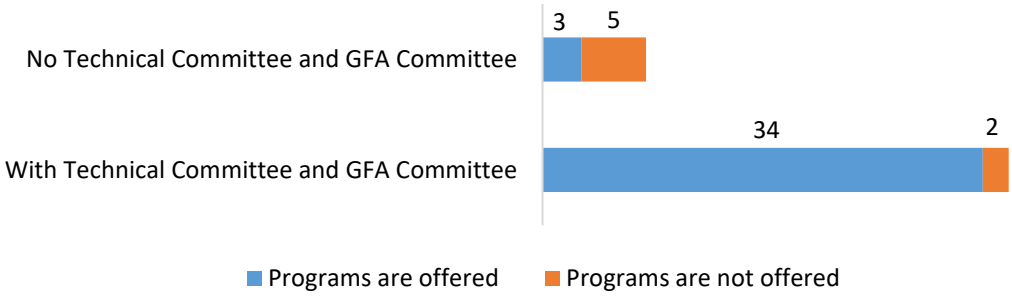

Figure 3. Relation between the offer of coach education programs and the existence of Technical Committees and GFA Committees.

7 NGFs out of 44 do not offer educational programs, 3 NGFs (Brazil, Azerbaijan, and Aruba) require only university education, which relieves them of their legal responsibility to provide continuing education for coaches. Additionally, 10 NGFs offer coach education opportunities although they do not require any education for gymnastics coaches (Cape Verde, Denmark, the United States, Finland, Cayman Islands, Italy, Mozambique, Namibia, Norway, and Sweden). While the concept of not requiring any type of mandatory education

was seen as a negative factor, we understand that NGFs do provide opportunities for their coaches that allow targeted access to these mediations. A similar situation is observed with the six NGFs that require higher education and also offer educational programs: Bangladesh, Benin, Qatar, Kosovo, Mongolia, and the Republic of Korea. Despite that, the efficiency of these programs, although not studied objectively, can be relativized with the analysis that will be presented later in this study.

Another case refers to NGFs that do not provide coach education programs but require specific education in gymnastics (Barbados, Mauritius, and Monaco), or both higher and specific education (Gran Canaria). The Barbados NGF reported that they recommend obtaining an approval from the FIG coach education program and the FIG Academy, which shows its importance for the development of gymnastics in this country. Other answers shed light on the NGFs in Mauritius, Monaco and Gran Canaria. The NGF in Mauritius requires that their coaches obtain support from other programs to participate in education programs, and the Monaco NGF stated that the required education follows the rules of the French education system. Similarly to Monaco, the Gran Canaria NGF follows the educational requirements of Spain.

Finally, we highlight the NGFs that offer such programs and require both types of education – higher education and specific education in gymnastics (Algeria, Luxembourg, Paraguay) and those that only require specific education (South Africa, Germany, Andorra, Argentina, Australia, Austria, Canada, Singapore, Slovakia, Estonia, Great Britain, Hong Kong, Ireland, Iceland, Libya, Portugal, Trinidad and Tobago, and Venezuela). Notably, these NGFs agree with our expectations that coaches' education needs to be regulated and provide programs for this purpose, thus offering an opportunity for mediated and intentional learning processes for coaches (Vygotsky, 1997).

The existence of Technical Committees and GFA Committees can enhance the learning processes of coaches as they support the development of educational programs by experts and people who are interested in certain areas of gymnastics, allowing for mediations at macro, medium and micro levels by experts in the field (Vygotsky, 1997).

Similarly, the provision of gymnastics coach programs shows emphasis on women's and men's artistic gymnastics. This highly relevant presence in NGFs – 75% of all programs offered – is consistent with the broad dissemination of this gymnastics discipline around the world, as it is traditional and secular (Nunomura et al., 2016; Quitzau, 2012; Soares, 2012). Another relevant factor is GFA, which is the third most recurrent type of gymnastics in the education programs for coaches. This is an interesting finding of this study since this is the main objective of this investigation and underlines the importance of studies related to this practice.

One of the aspects to be highlighted is the importance given to the practice of essentially non-competitive gymnastics, which is what GFA stands for when compared to other competitive and even Olympic disciplines. GFA, although it can be interpreted in different ways, is generally considered a practice focused on leisure and inclusion of people of different technical levels and motivations with no specific sporting goals (Fiorin-Fuglsang & Paoliello, 2008). Thus, the offer of coach education programs based on this approach to gymnastics practice highlights the interest of administrative institutions in the dissemination of gymnastics and the possibility of making this practice a pillar of NGFs; this paves the way to the development of other gymnastic disciplines as a starting point to sport careers. From a pedagogical perspective, GFA can potentially use pedagogical strategies that allow for the development of fairer social

relationships. The dissemination of this practice seems to be a positive aspect for the social groups involved.

After women's and men's artistic gymnastics and GFA, the most common gymnastic disciplines in coach education programs are Olympic, rhythmic, and trampoline gymnastics, followed by those organized by the FIG, i.e., aerobic and acrobatic gymnastics. Another aspect observed in the results is the offer of programs for other gymnastic disciplines and practices, such as TeamGym and rope skipping, which are popular in some localities and have received varied attention in different countries and regions. Other practices mentioned, such as aesthetic gymnastics, freestyle gymnastics, cheerleading, gymnastics for preschool children and gymnastics for people with disabilities, ball games, health and dance activities, gymnastics for children, and choreography show the gymnastic practices that are most valued by each NGF.

CONCLUSION

This study presented the first and unprecedented effort to analyze education requirements to work in gymnastics and the provision of educational programs for coaches. As a result, we found that, in general, NGFs offer education programs for coaches, regardless of whether their respective legislations stipulate specific education in gymnastics as mandatory.

Therefore, we conclude that a relationship was found between the existence of Technical and GFA Committees and the organization of education programs for coaches, since the NGFs with these committees almost always offer such programs. This hypothesis can be verified on the example of GFA: the NGFs that offer GFA programs are, in general, those that have GFA Committees. It has been established that most NGFs require specific education in gymnastics or do not require any training at all.

Brazil, for example, can provide a mirror to what might happen in other countries, especially nations whose regulatory institutions are in a consolidation process. In the last year in Brazil, many presentations and debates about the practice and its events were carried out in a virtual space, and this led to changes in the data found in the research. Notably, the growing number of GFA Committees in state gymnastics federations in Brazil, when comparing the current data with those obtained by Carbinatto, Toledo e Massaro (2016), may represent an advance in the promotion of continuing education programs in GFA in this country, as well as encouraging other actions at the national and federal levels.

Finally, our study highlights the relevance of education courses offered by NGFs, the great potential for the development of gymnastics in their respective countries and localities, and the importance of internal organization of the institutions to enhance the efforts focused on gymnastics.

ACKOWLEGDEMENT

This study was partly financed by the Coordination for the Improvement of Higher Education Personnel - Brasil (CAPES) - Finance Code 001.

This study was partly financed by the National Council for Scientific and Technological Development - Brasil (CNPq) - Finance Code 140354/2016-6.

REFERENCES

Carbinatto, M. V.; Toledo, E., & Massaro, I. F. (2016). Estrutura e organização da Ginástica para todos: uma análise federativa [Structure and organization of Gymnastics for All: a federative analysis]. In M. F. de Oliveira, & E. de Toledo (Eds.), *Ginástica para todo*s: possibilidades de formação e intervenção (pp. 43-67). Anápolis, GO: UEG.

Cushion, C. J., Armour, K. M., & Jones, R. L. (2003). Coach Education and Continuing Professional Development: experience and learning to coach. *Quest*, 55, 215-230.

Fiorin-Fuglsang, C. M., & Paoliello, E. (2008). Possíveis relações entre a Ginástica Geral e o lazer [Possible relations between Gymnastics for All and leisure]. In E. Paoliello (Eds.), *Ginástica Geral* – Experiências e reflexões (pp. 97-120). São Paulo, SP: Phorte.

Flick, U. (2009). *Desenho da pesquisa qualitativa* [Qualitative research design]. Porto Alegre, RS: Artmed.

International Council for Coaching Excellence (ICCE) (2013). *International Sport Coaching Framework Version 1.2*. Champaign: Human Kinetics.

Jones, R. L., Morgan, K., & Harris, K. (2012). Developing coaching pedagogy: seeking a better integration of theory and practice. *Sport, Education and Society*, 17(3), 313-329.

Jones, R. L., & Thomas, G. L. (2015). Coaching as 'scaffolded' practice: further insights into sport pedagogy. *Sports Coaching Review*, 4(2), 65-79.

Lakatos, E. M., Marconi, M. A. (2013). *Fundamentos de metodologia científica* [Foundations of scientific methods]. (5th ed.). São Paulo, SP: Atlas.

Mallett, C. J., Trudel, P., Lyle, J. & Rynne, S. B. (2009). Formal vs. Informal Coach Education. *International Journal of Sports Science & Coaching*, 4(3), 325-334.

Milistetd, M. (2015). A aprendizagem professional de treinadores esportivos: análise das estratégias de formação inicial em Educação Física [The professional learning of coaches: analysis of the strategies of initial education in Physical Education]. *Doctoral dissertation*. Florianópolios: Universidade Federal de Santa Catarina, Centro de Desportos.

Morgan, K., Jones, R. L., Gilbourne, D., & Llewellyn, D. (2013). Innovative approaches in coach education pedagogy. *Nuances:* estudos sobre Educação, 24(1), 218-234.

Nunomura, M. et al. Fundamentos da Ginástica Artística [Foundations of Artistic Gymnastics]. In: M. Nunomura (Org.). *Fundamentos das Ginásticas* (2nd ed., 211-255). Várzea Paulista, SP: Fontoura.

Patrício, T. L., Bortoleto, M. A. C., & Carbinatto, M. V. (2016). Festivais de ginástica no mundo e no Brasil: reflexões gerais [Gymnastics festivals around the world and in Brazil: general reflections]. *Revista Brasileira de Educação Física e Esporte*, 30(1), 199-216.

Piggott, D. (2012). Coaches' experiences of formal coach education: a critical sociological investigation. *Sport, Education and Society*, 17(4), 535-554. doi: 10.1080/13573322.2011.608949.

Quitzau, E. A. (2012). "O trabalho na forma de alegria juvenil": a ginástica segundo Johann Christoph Friedrich Guts Muths ["Labor in the garb of youthful mirth": gymnastics according to Johann Christoph Friedrich Guts Muths]. *Revista Brasileira de Ciências do Esporte*, 34(2), 359-373.

Soares, C. L. (2012). *Educação física:* raízes europeias e Brasil [Physical education: European and Brazilian roots]. Campinas, SP: Autores Associados.

Triviños, A. (1987). *Introdução à pesquisa em ciências sociais:* a pesquisa qualitativa em educação [Introduction to social sciences: qualitative research in education]. São Paulo, SP: Atlas.

Vygotsky, L. S. (1997). *Obras escogidas* [Choosen works]. Madrid: Visor.

Vygotsky, L. S. (1998). *A formação social da mente* [Mind in society]. (4th ed.). São Paulo, SP: Martins Fontes.

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Article received: 10.11.2022
Article accepted: 10.12.2022

SHORT HISTORICAL NOTES XXVI

Anton Gajdoš, Bratislava, Slovakia

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

Eberhard Gienger (July, 21, 1951, Kunzelsau, Germany)

Ebergard Gienger was one of the world best high bar gymnasts in period between 1971 and 1981. Even today his name is used at almost every high performance international championship, as he was the first to perform on high bar salto backward piked with 180 degrees turn into regrasp. Element named by Gienger – Gienger salto – is today performed on horizontawl bar and on uneven bars.

Photo on right by: Albrecht Gaebele

Gienger salto as is drawn in FIG Code of Points since 1977

As he was very tall gymnast, by his words before training session his body height was 177 cm and after one centimeter less. Beside high bar, he was very succesfull on pommel horse and parallel bars, however his height was very contradictory towards rings exercises.

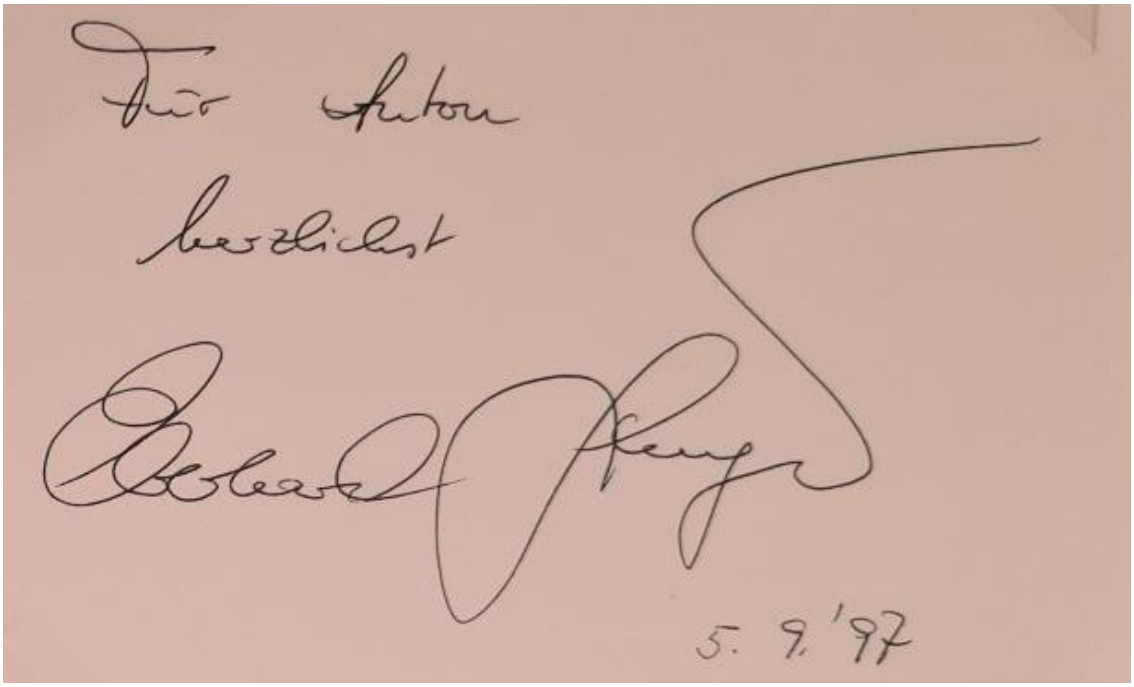
The first big international competition he attended was European Championship in 1971 in Madrid, where he took 6th place on vault and his last at European Championship in 1981 in Rome, where he won on horizontal bar and placed third on parallel bars.

Photo on left by: Albrecht Gaebele

His most prominent results are:

OG	Muenchen	1972	5. Team, 14. AA
OG	Montreal	1976	3. HB, 5.team, 16. AA
WC	Varna	1974	1. HB
WC	Strssbourg	1978	2. HB, 2. PH, 4. AA, 6 PB
WC	Moscow	1981	2. HB, 8.PB
EC	Madrid	1971	6. VT
EC	Grenoble	1973	1. HB
EC	Bern	1975	2. AA, 2. HB, 3. PH
EC	Vilnius	1977	2. PB
EC	Essen	1979	3. PB
EC	Rome	1981	1. HB, 3. PB
WCup	London	1975	2. HB, 4. AA
Wcup	Oviedo	1977	1. HB, 5. AA
Wcup	Sao Paulo	1978	1. HB, 2. PB, 6. AA
Wcup	Tokyo	1979	1. HB

During his very succesfull sports career, he was named twice as German Sportsmen of the year in 1974 and 1978, and became teacher of physical education. After retirement from gymnastics he was among many functions he had, member of German National Olympic Committee, FIG Men's technical committee and from 2001 he was for twenty years member of German Parliament and serving in the Committee for Sports and Committee on Education, Research and Technology assessment.



Slovenski izvlečki / Slovene Abstracts

Željko Iveljić, Dan Lanc, Kamenka Živčić, Lucija Milčić

RAZVOJ TELOVADBE NA HRVAŠKEM DO LETA 1903

Namen prispevka je bil prikazati razvoj telovadbe na Hrvaškem do leta 1903. Gre za časovni opis razvoja telovadbe na Hrvaškem od leta 1859 do 1903. V Osijeku je bilo leta 1865 ustanovljeno prvo hrvaško telovadno društvo. Telovadbo so uvedli v šole sredi 19. stoletja kot posledica povečanega zanimanja za telesno vzgojo na podlagi močnejšega razvoja civilne družbe. Leta 1874. je bil v Zagrebu ustanovljen Hrvatski sokol in tudi telovadba je postala del srednješolskega programa. Na Hrvaškem so začela nastajati številna telovadna društva, med drugim leta 1878 Varaždinsko telovadno društvo Sokol in leta 1876 Zadarsko telovadno društvo. V Dalmaciji, osrednji Hrvaški in Slavoniji so bila ustanovljena nova telovadna društva. Hrvaški sokol je bil na primer ustanovljen leta 1884 v Bjelovarju in leta 1894 v Makarski. Poleg tega je telovadno društvo sodelovalo na javni telovadbi v Pragi in Parizu. Ženska telovadba se je začela leta 1891 v Hrvaškem sokolu v Zagrebu, kjer so vaje potekale v treh skupinah med drugim v prostih vajah in vajah na orodju.

Ključne besede: orodna telovadba, Hrvaška, zgodovina, “Sokol”.

Barbara Jakše in Boštjan Jakše

PRIMERJAVA ŠTIRILETNEGA CIKLA PREHRANSKEGA IN SRČNOŽILNEGA ZDRAVSTVENEGA STANJA VRHUNSKE TELOVADKE: POROČILO O ŠTUDIJI PRIMERA IZ SLOVENIJE

Redno spremljanje telesne sestave, prehrane, zdravja in gibalnih sposobnosti je ključnega pomena za nadaljnje načrtovanje vadbe. Z enakim merskim postopkom smo ovrednotili štiriletno spremembo (leta 2018 in 2022) v prehranskem in srčnožilnem zdravstvenem stanju trenutno najuspešnejše odrasle orodne telovadke na vrhunski ravni v Sloveniji. Podrobno telesno sestavo in prehranski vnos so ocenili z uporabo rentgenske absorpciometrije z dvojno energijo in veljavnega vprašalnika o hrani FFQ. Izmerjeni so bili krvni lipidi in varnostni dejavniki, krvni tlak in mikrohranila v serumu (npr. B12, 25-hidroksivitamin D (25(OH)D), kalij, kalcij, fosfor, magnezij in železo). Štiriletna primerjava je pokazala izboljšano stanje sestave telesa: zmanjšana masa/odstotek telesne maščobe, odstotek androidne maščobe in razmerje android/ginoid, medtem ko so druge telesne spremenljivke ostale v bistvu nespremenjeni. Izmerili smo tudi izboljšanje nekaterih in poslabšanje drugih serumskih spremenljivk zdravja srca in ožilja (tj. znižan skupni holesterol, vendar povečan holesterol lipoproteinov nizke gostote in S-glukoza), najverjetneje zaradi razlik v ocenjenem prehranskem vnosu (tj. nižja skupna maščoba, vnos enkrat in večkrat nenasičenih maščobnih kislin, vendar višji vnos holesterola in še vedno visok vnos prostega sladkorja in nasičenih maščob, kljub večji količini vlaknin). Predvsem so bili vnosi hranil, ki so na splošno zaskrbljujoči (vlaknine (mejno nizek vnos), eikozapentaenojske omega-3 maščobne kisline in dokozaheksaenojske omega-3 maščobne kisline, vitamina B12 in D, kalcij (mejno nizek vnos), železo in cink) v skladu s priporočenimi razponi. Vendar pa vnos vitamina E in kalija za športnico ni bil ustrezen. Poleg tega športnica v letu 2018 ni uživala prehranskih dopolnil, zdaj pa redno uživa več prehranskih dopolnil, med drugim obogatene rastlinske beljakovine v prahu, izoliran vitamin B12, C, D in železo. Športnica je imela bistveno nižje serumske vrednosti 25(OH)D od priporočenih, verjetno zaradi nezadostnega rednega vnosa vitamina D v obliki prehranskega dopolnila (1000 IE/d). Glede na serumske ravni mikrohranil, fosforja in železa, ki so odstopale od primerjalnih vrednosti v študiji iz leta 2018, je bilo v trenutni študiji ugotovljeno, da so znotraj primerjalnih razponov (tj. stanje železa se je izrazito izboljšalo). Ta vrsta orodja za pregledovanje, ki uporablja veljavne, občutljive in cenovno dostopne metode ter s hitro organizacijsko uporabo, je lahko izvedljiva oblika rednega spremljanja.

Ključne besede: vrhunska športnica, orodna telovadka, telesna sestava, mineralna kostna gostota, prehrana, mikrohranila, 25-hidroksivitamin D, zdravje srca in ožilja.

Isaura Leite, Pedro Fonseca, Lurdes Ávila Carvalho, João Paulo Vilas-Boas, Márcio Goethel, Luis Mochizuki and Filipe Conceição

STANJE V TEKMOVALNI AKROBATIKI: BIBLIOMETRIJSKA ANALIZA

Ker je tekmovalna akrobatika nova, le nekaj desetletij stara telovadna disciplina, kot znanstveno raziskovalno področje še ni dovolj raziskana. Kljub vse večji priljubljenosti in čeprav je znanstveno kartiranje postalo bistvena dejavnost za vse znanstvene discipline, bibliometrična analiza na to temo ni bila na voljo. Zato je cilj te študije zagotoviti statično sliko razvoja znanstvenih raziskav v tekmovalni akrobatiki z zbiranjem informacij o glavnih avtorjih, pa tudi o glavnih temah raziskovanja, dinamiki objav in omrežjih sodelovanja. Iskanje v zbirkah podatkov Web of Science in Scopus je odkrilo 37 člankov iz revij med letoma 2001 in 2021. Rezultati kažejo, da je bilo leto 2015 mejnik za znanstveno raziskovanje tekmovalni akrobatiki, saj je zaznamovalo začetek prevlade avtorjev iz Španije, sledita pa ji Poljska in Portugalska. Države so na splošno osredotočene na lastno ozemlje in obstaja omejeno znanstveno sodelovanje med različnimi narodi. Španske in poljske raziskovalne ustanove so vodilne v tem športu. Kot primerjava za prihodnje študije naši rezultati kažejo, da čeprav je bilo ravnotežje opredeljeno kot tema posebne raziskave, ni bilo zanimanja za ravnotežje piramid, ki je glavna značilnost tekmovalne akrobatike.

Ključne besede: tekmovalne akrobatike; bibliometrična analiza; znanstvena produkcija.

Masaharu Matsushima

POVEZANOST MED GIBANJEM V SKOKIH IN MIŠIČNO DEJAVNOSTJO MED SALTOM NA VELIKI PROŽNI PONJAVI: ŠTUDIJA PRIMERA

Ta študija je raziskovala razmerje med gibanjem v skokih in mišično dejavnostjo med salti na veliki prožni ponjavi. Sodelovalo je 10 akrobatov (3 vrhunskih in 7 dobrih). Po merskem postopku so akrobati na veliki prožni ponjavi izvedli salto nazaj skrčeno in salto naprej skrčeno s pol obrata (Barani). Meritve so bile izvedene z elektromiogramom (EMG) in slikovno razčlenitvijo. Skok je bil opredeljen kot "100 ms pred dotikom", 100 ms preden je akrobat sodkočil na ponjavi; "dotik" v trenutku stika s ponjavo; "najnižje" v trenutku spuščanja in "odriv" v trenutku zapuščanja ponjave. Opredeljena so bila časovna obdobja kot »čas pred dotikom« od »100 ms pred dotikom« do »dotik«; kot "del navzdol" od "dotik" do "najnižje" in kot "navzgor" od "najnižje" do "odriv". Posledično so bili koti naklona trupa udeležencev na visoki in srednji ravni glede na salto nazaj (srednja raven 4,3±1,3°, visoka raven 7,0±2,4°) in Barani (srednja raven 9,2±1,7°, visoka raven 9,4±1,7°) med najnižjim delom so bili naklonjeni naprej. Bistvenih razlik ni bilo. Razpon EMG preme trebušne mišice ($p < 0,05$) med »navzgor« in iztegovalke trupa ($p < 0,01$) med »pred dotikom« je bila bistveno višja v skupini na visoki ravni. Trup je bil nagnjen z uporabo iztegovalk trupa kot pri visoki ravni med »100 ms pred dotikom« in »najnižjo«. Togost trupa z dejavnostjo preme trebušne mišice je bilo učinkovito gibanje spodnje okončine v času »navzgor«.

Ključne besede: velika prožna ponjava, salto nazaj, salto naprej s pol obrata, EMG, odriv.

Damla Ercan Köse, Tolga Akşit, Osman Açıkgöz, Gamze Ceyhan

ČASOVNI POTEK SPREMEMB PRI VSKOKU RAZNOŽNO PREDNOŽNO IN VSKOKU STEGNJENO PO ENKRATNEM STATIČNEM RAZTEZANJU PRI ORODNIH TELOVADKAH

Namen raziskave je bil preučiti časovni potek sprememb učinkov statičnega raztezanja na vskok raznožno prednožno, višino vskoka in gibljivost po izvajanju dinamičnih gibov pri orodnih telovadkah. V raziskavi je sodelovalo 14 orodnih telovadk, starih od 9 do 14 let. Višine vskoka stegnjeno so bile izmerjene s testno napravo New Test 2000. Merjenje gibljivosti je bilo izvedeno s testom gibljivosti pri sedenju in dosegu. Gibanje vskokov, specifično za orodno telovadbo, je bilo ovrednoteno glede na kot med spodnjimi okončinami s programom za razčlenitev gibanja »Dartfish«. Ocenjene so bile osnovne meritve, opravljene pred običajnim ogrevanjem, in meritve, opravljene po statičnem raztezanju. Izvedene so bile štiri serije telovadnih gibov, vsaka je trajala dve minuti. Meritve so bile ponovljene po vsaki seriji. Ugotovljeno je bilo, da statično raztezanje pomembno vpliva na izvedbo vskoka stegnjeno. Pomembne razlike so bile ugotovljene med skoraj vsemi pari skokov. Pri spremembah, povezanih z gibljivostjo so bile ugotovljene razlike le pre nekterih parih. Ugotovljeno je bilo, da statično raztezanje nima pomembnega vpliva na izvedbo vskoka prednožno raznožno. Skratka, čeprav je izvedba statičnega raztezanja znatno znižal izvedbo vskoka stegnejno, ni vplival na vskok, specifičen za orodno telovadbo. Negativni učinki statičnega raztezanja na višino vskoka so se približali osnovni vrednosti približno 4 minute kasneje.

Ključne besede: orodna telovadba, statično raztezanje, skok stegnjeno, gibljivost.

Tynan F. Gable, Michael M. Lockard

UČINKOVITOST VADBE RAVNOTEŽJA NA IZBOLJŠANJE RAVNOTEŽJA MLADIH TELOVADK

Telovadba je priljubljen šport, ki ima koristi za moč, gibljivost in osebno rast športnikov. Tako statično kot dinamično ravnotežje se razvijata od mladosti in sta bistvenega pomena za telovadbo na višjih težavnostnih stopnjah. Namen je bil oceniti učinkovitost vadbe ravnotežja pri izboljšanju dinamičnega ravnotežja mladih telovadk. 19 mladinskih olimpijskih telovadk (JO) stopnje 3, starih od 6 do 11 let, je bilo naključno razporejenih v skupine za vadbo ravnotežja (BT) ali nadzorne skupine. Skupina BT je med vsako vadbo opravila različne vaje za ravnotežje (2x/teden osem tednov), vključno z ravnotežjem na eni nogi, vajami za izboljšanje skokov in skoki na površine z različno elastičnostjo. Telovadke v nadzorni skupini so nadaljevali z običajnimi telovadnimi nalogami. Telovadke so bile merjene pred vadbo, po 4. tednu in po 8. tednu, da bi ocenili izboljšave v sistemu točkovanja napak ravnotežja (BESS), ravnotežju »zvezda« (SEBT), dolžini poti pritiska (dolžina poti COP) in zaznavanju položaja sklepov (JPS). Opaženo je bilo izboljšanje SEBT za prevladujočo nogo telovadk ($p=0,03$). V nasprotnem primeru ni bilo pomembnih razlik med izboljšavami v rezultatih za nadzorno skupino in poskusno skupino. Telovadke JO stopnje 3, ki so na začetku svoje tekmovalne poti, niso imele nobene dodatne koristi od vadbe ravnotežja dvakrat tedensko, razen običajno predpisane vadbe in vadbe spretnosti. Čeprav nezanesljivi dokazi kažejo na možen kratkotrajen učinek na ravnotežje takoj po vajah za ravnotežje, so potrebne nadaljnje raziskave.

Ključne besede: propriocepcija, mladinska olimpijska telovadba USAG, ravnotežje, vestibular.

Ece Aydin, Pelin Gönkek, Eylül Kilinçkay, Cemre Gökçin Akken, Kadriye Bayer, Emine Kutlay

RAZČLENITEV PREVLADUJOČE ROKE-STOPALA/NOGE PRI IZVEDBI PRVIN TEŽAVNOSTI VRHUNSKIH RITMIČARK

Namen je bil ugotoviti število in razmerje prevladujoče roke-stopala/noge pri izvedbi prvin težavnosti vrhunskih ritmičark v sestavah. Na tekmah svetovnega pokala in evropskih prvenstvih, ki so potekala leta 2021, so bile pregledane finalne tekmovalne sestave (N=75) telovadk (N=28), določene so bile prvine težavnosti s telesom in orodji ter število in stopnja uporabe prevladujoče strani. Ker so se telovadke udeležile več kot enega tekmovanja, so bile v raziskavo vključene njihove zadnje tekmovalne sestave. Podatki so bili pridobljeni z razčlenitvijo sestav, posnetih med tekmovanji. Statistične razčlenitve podatkov je bila izvedena s statističnim programom IBM SPSS 25.0. V vseh sestavah so bile višje stopnje med 56,2 % in 87 %, uporabe desne roke, pri metanju in lovljenju, višje stopnje so bile ugotovljene pri obroču in traku pri metanju z levo nogo v primerjavi z desno nogo. Pri prijemu desnega stopala/noge so bile najvišje stopnje opažene pri sestavi z obročem (49,6 %). Pri uporabi leve noge je bila prednost med 65,1 % in 97,4 %, pri sonožnih in enonožnih skokih med 58 % in 71 % pri prvinah ravnotežja. Pri obratih je imela uporaba desne noge višje stopnje, med 72,6 % in 80 %. Ritmičarke so bolj uporabljale desno roko pretežno pri metih in prijemih, levo nogo pri skokih/poskokih in ravnotežjih ter desno nogo pri obratih.

Ključne besede: ritmika, sestave, meti, lovljenja, ravnotežja, obrati.

Tamiris Lima Patricio and Michele Viviene Carbinatto

ŽIVE IZKUŠNJE UDELEŽENCEV SVETOVNE GIMNAESTRADE: PRIZNANJE "ZA VSE"

Udeležba na dogodkih je predvsem zaradi izkušenj. Te izkušnje so edinstvene za posameznike. Iz znanosti o oblikovanju duha, ko živimo svet, spoznavamo stvari in misli. To delovanje gradi našo osebnost in širi naše bivanje v svetu. Namen tega članka je razmišljati o življenjskih izkušnjah 16 udeležencev ekipe Telovadbe za vse (GfA) na dogodku XVI. Svetovne Gimnaestrade (WG). Uporabljena so bila opazovanja in poglobljeni pogovori, na katerih je bila opravljena kakovostna razčlenitev. Veljavnost in zanesljivost sta bili zagotovljeni s kritičnim prijateljem, pregledom članov in umeritvijo podatkov. Rezultati so pokazali, da tudi ob predhodnih podatkih o dogodku telovadci in osebje niso imeli pravega občutka razsežnosti WG. To priznanje je prišlo s prisotnostjo na dogodku. Poudarili so, da ne gre le za veliko število ljudi – gre za združevanje različnih ljudi; ni šlo za določeno panogo telovadbe, temveč za vse panoge skupaj; ne o običajnih telovadnih orodjih, temveč o telovadbi z uporabo različnih predmetov. Za njih je številčnost GfA zaživela v gibih, predstavah, temah in osebnostih telovadcev. Zaradi tega so verjeli, da so telovadci. Poleg tega so bila zapisana razmišljanja o telesno kulturnem dogodku brez tekmovanja in strokovni razvoj. Upravljanje, preučevanje in raziskovanje GfA je pomembno. Vendar pa je treba spodbujanje osebnih izkušenj na telovadnih dogodkih v živo ceniti tudi kot učinkovit prostor za učenje, očaranje in oglaševanje GfA.

Ključne besede: telovadba; športni dogodki; kvalitativne raziskave.

Lucas Machado de Oliveira, Vitor Ciampolini, Michel Milistetd, Ieda Parra Barbosa-Rinaldi in Juliana Pizani

ZAHTEVE VADITELJEV ORODNE TELOVADBE NA ZAČETKIH NJIHOVE POTI

Visoka kakovost delovanja športnih vaditeljev vključuje uporabo poklicnih, medosebnih in osebnih veščin (Côté & Gilbert, 2009). Zahtevnost dela športnih vaditeljev, zlasti v orodni telovadbi (AG), je zaradi mnogih tehničnih in fizičnih zahtev že v osnovnih kategorijah lahko povečana za vaditelje z malo izkušnjami, ki vstopijo na to področje. Zato je bila ta študija namenjena ugotavljanju dojemanja vaditeljev na začetku njihove poti glede vrst veščin, potrebnih za njihovo poklicno delovanje. Izprašali so pet vaditeljev, povezanih s telovadno zvezo Santa Catarina (Brazilija), z manj kot 10-letnimi izkušnjami v AG. Med pogovori so bili obravnavani kazalniki, kot sta poklicne veščine in znanje, potrebno za delovanje. Za razčlenitev podatkov je bila uporabljena Braunovo in Clarkeovo (2019) zrcalna področna razčlenitev. Rezultati kažejo, da zahtevnost dela vaditeljev zahteva razširjen obseg znanja. Na splošno se vaditelji zavedajo, da so ustrezne strokovne in medosebne veščine za poučevanje telovadbe najbolj zahtevana znanja v vsakodnevnem delovanju. Medosebne veščine pa se zdijo manj potrebne, kar lahko prispeva k ohranjanju podobe kulture osebnosti pri športni vadbi. Zahteve, obravnavane v tej raziskavi, vodijo do uporabe in razmislekov o programih usposabljanja vaditeljev AG, zlasti v strukturi celote znanja, ki zagotavlja dobro osnovo za soočanje z njihovimi dnevnimi izzivi.

Ključne besede: strokovni razvoj, strokovno delo, vaditeljsko znanje.

Daniela Bento-Soares in Laurita Marconi Schiavon

PONUDBA URADNEGA USPOSABLJANJE DRŽAVNIH TELOVADNIH ZVEZ ZA VADITELJE VADBE TELOVADBE ZA VSE: MEDNARODNA PRIMERJAVA

Načrti usposabljanja vaditeljev za vadbo telovadbe za vse državnih telovadnih zvez (NGF) lahko zagotovijo poglobljene in posebne razprave ter prispevajo k razvoju telovadbe v različnih državah, saj obravnavajo posebna zanimanja in ljudi. Za izvedbo teh ukrepov je potrebna določena stopnja organiziranosti ustanov in obstoj posebnih odborov ali komisij lahko prispeva k temu, saj poznajo področje in poznajo organizacijo ustreznih delovanj. Namen raziskave je bil preveriti ponudbo načrtov usposabljanja vaditelje za telovadbo za vse (GFA) in organizacijo NGF po vsem svetu. O obstoju takšnih odborov ali komisij in spodbujanju načrtov usposabljanja vaditeljev za GFA in druge oblike telovadbe smo se posvetovali s skupno 44 NGF. Uporabili smo spletni vprašalnik, ki gostuje na Google Forms® v štirih jezikih. Odgovore smo obdelali s preprosto statistiko in razčlenili glede na raziskovalne cilje. Iz pridobljenih odgovorov je razvidno, da ima 36 NGF v svoji organizaciji tehnične GFA komisije, medtem ko jih osem nima (manjše institucije in še vedno slabo strukturirane). 30 NGF je trdilo, da imajo odbore GFA, kar je pomembno število. Poleg tega 30 NGF izvaja načrte usposabljanja vaditeljev za GFA. Rezultati so pokazali, da obstaja ujemanje med obstojem tehničnih odborov in odborov GFA ter organizacijo in oglaševanjem načrtov usposabljanja vaditeljev.

Ključne besede: strokovno izobraževanje; vaditelji, uposabljanje.

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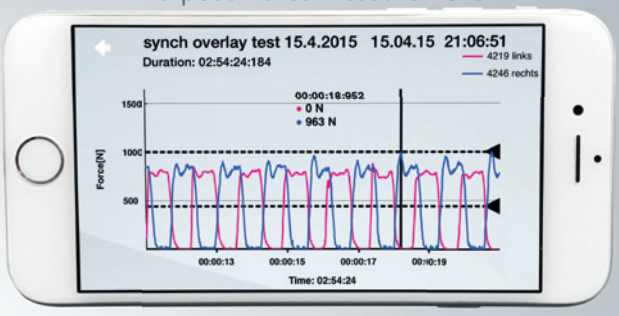

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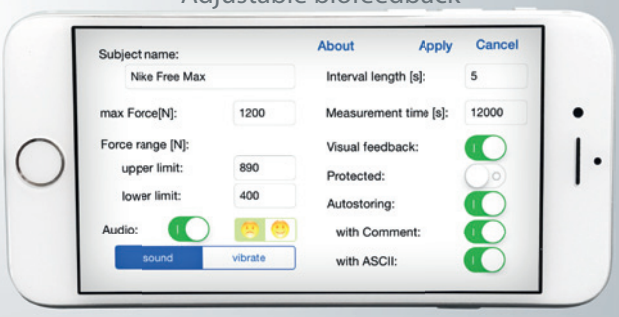

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Science of Gymnastics Journal (ScGYM®)

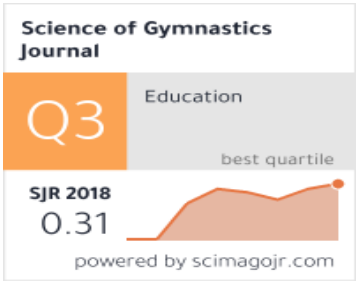
(e-ISSN 1855-7171)

Science of Gymnastics Journal is indexed in:
Web of Science (ESCI data base, since 2015), EBSCOhost SPORTDiscus, SCOPUS, COBISS (IZUM), SIRC (Canada), ERIHPLUS, OPEN. J-GATE,
GET CITED, ELECTRONIC JOURNALS INDEX, SCIRUS, NEW JOUR, GOOGLE SCHOLAR, PRO QUEST and INDEX COPERNICUS.

ScGYM® (ISSN 1855-7171) is an international online journal published three times a year (February, June, October).

Front page design: Sandi Radovan, Slovenia.

Published by: University of Ljubljana Press (Založba Univerze v Ljubljani)
For the Publisher: Gregor Majdič, Rector of the University of Ljubljana
Issued by: *University of Ljubljana, Faculty of Sport, Department of Gymnastics*
For the Issuer: Damir Karpljuk, the Dean of the Faculty of Sport UL



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E-mail: scgym@fsp.uni-lj.si
Home page: http://www.scienceofgymnastics.com & https://journals.uni-lj.si/sgj/

Publication is free of charge.

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

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Fundacija za šport

Slovenian Research Agency

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