IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

Evaluation of Balance, Core Muscle Endurance and Flexibility of Lower Limb In Rhythmic Gymnasts And Ballet Trained Rhythmic Gymnasts: A Cross Sectional Study.

Dr. Anisha Gulati (PT)[1]- Corresponding Author

Assistant Professor[1], Musculoskeletal Physiotherapy, Department of Physiotherapy, MGM School of Physiotherapy, Navi Mumbai, India.

Avani Dixit Shivani ChavanNeha Damle Mubarak Desai Vidhi Desai

Intern, MGM School of Physiotherapy, Navi Mumbai, India.

Research proposal submitted to MGM School of Physiotherapy, Kamothe, Navi MumbaiIn the partial fulfilment of regulations for the award of the degree of Bachelor of Physiotherapy.

Through

MGM School of Physiotherapy,Kamothe, Navi Mumbai.

Batch (2017-2022)

ABSTRACT

Background: Gymnastics is esteemed to be the mother of all sports. Rhythmic Gymnastics is a sport that combines the elements of Gymnastics techniques, Ballet and apparatus manipulation to perform perfectly coordinated movements on beats of music. To execute static positions and dynamic elements, such as jumps, pirouettes and acrobatic movements, balance is required. High-level of core endurance is needed to perform technical movements. Flexibility, both active and passive, is one of the physical abilities that also plays an important role in Rhythmic Gymnasts. Balance, core muscle endurance and lower limb flexibility thus stands out to be some of the few essential components that work hand in hand to bring about elegant and graceful movements performed by a Rhythmic Gymnast. This study thus aims to evaluate balance, core muscle endurance and flexibility of lower limb in Rhythmic Gymnasts and Ballet trained Rhythmic Gymnasts.

Methodology: A cross sectional study was carried out on 30 Gymnasts from age 8-20 years by the means of purposive sampling. First, the gymnasts performed their usual training warmup prior to the testing. The investigators- one of them being a rhythmic gymnastics judge, was able to evaluate the test with precision. Balance test in the Arabesque position, Balance test in Back-grab position, Balance test in the Heel stretch position, Movement from the Arabesque to the Passé position were used to compare the balance, McGill's torso muscular endurance test battery was used to compare the endurance, Battery of lower limb flexibility tests of Federation International was used to compare the lower limb flexibility. The identified movements were entered in a Microsoft Excel spreadsheet, according to the frequency with which they appeared in the compositions. Data was analysed using the SPSS software version (24). Results were described in a tabular and graphical representation.

Results: In balance test 1 group A and group B show significant difference with p value being
0.00 ; test 2 group and group B show significant difference with p value being 0.00 ; test 3 group A and group B show significant difference with p value being 0.00 ; test 4 group A and group B show significant difference with p value being 0.001.In core muscle endurance test 1 group A and group B show significant difference with p value being 0.01 ; test 2 group A and group B show significant difference with p value being 0.022 ; test 3 group A and group B show significant difference with p value being 0.03 ; test 4 group A and group B showsignificant difference with p value being 0.01.Flexibility tests of preferred lower limb group A and B show significant difference with p value of test01, test02, test03, test04, test07 being
0.00 and p value of test05 being 0.010 and test06 being 0.011and that of non-preferred lower limb group A and group B show significant difference with p value test02 being 0.05, test03, test04 and test06 being 0.0, test05 being 0.01 and test07 being 0.01. However, there was no significant difference seen in test 01 of non-preferred lower limb group A and group B with the p value of 0.158.

Conclusion: From this study we conclude that Ballet trained Rhythmic Gymnasts exhibited far better balance, core muscle endurance and flexibility of lower limb than Rhythmic Gymnasts. Hence, incorporating Ballet training along with skill-based training can be beneficial for the Gymnasts.

Keywords: Rhythmic Gymnasts, Ballet, balance, core muscle endurance, flexibility of lower limb, athletes, Ballet movements.

INTRODUCTION

Gymnastics is esteemed to be the mother of all sports. It is an international level Olympic sport performed in three different categories based on the apparatus used and the type of exercises involved. These include men's and women's Artistic

Gymnastics; Trampoline Gymnastics and Rhythmic Gymnastics (RG). [1]

Rhythmic Gymnastics is a modern form of Gymnastics. It is a sport that combines the elements of Gymnastics techniques, Ballet and apparatus manipulation to perform perfectly coordinated movements on beats of music. It is performed using five apparatus programs: Hoop, ball, clubs, ribbon and rope for individual routines. The group events either use a single apparatus or two.[2] While analysing the demands of the sport, an increased level of development in determinantssuch as motor skills, flexibility, strength, endurance, coordination, agility, rhythm and balanceis required in Rhythmic Gymnastics.[3] [4] [5]

From dance and athletics to everyday life, balance is an integral component of movement. Balance is greatest when the body's centre of gravity is maintained over its base of support. Postural control is one of the determining factors of Balance. It relies on the interaction of the vestibular, visual and somatosensory systems. When the body is in equilibrium with the forces acting, stable support over a very small surface area (relevé) during exercises is achieved.[6][7] To maintain balance, good flexibility and good core muscle endurance is needed. In Rhythmic Gymnasts, balance is of utmost importance for the execution of static positions and dynamic technical elements, such as jumps, pirouettes and acrobatic movements. [8]

The core functions as a muscular corset that provides stability to the body and spine.[9] To perform a maximum number of strength elements in a gymnastics competition routine, a high- level core muscle endurance is required.[10]This occurs when the relatively high-power outputis maintained for 30-60 seconds. This could be, for example, in a series of jumps.[11]Strong Core stability allows complete force transmission developed with the lower extremities through the lumbopelvic musculature and hip complex to the upper extremities and thus provides trunk control and balance.[12]Therefore, adequate development of core endurance in Rhythmic Gymnasts could evoke an increase in sporting performance for better execution andmaintenance of technical elements. [13][14]

Flexibility plays a key role in Rhythmic Gymnasts. It is one of the physical abilities needed in the sport of Rhythmic Gymnastics due to its need to perform movements in a wide range of motion[15] Flexibility enhances the possibility of executing different movements, thus, resulting in the increase of the gymnasts' technical level Active flexibility can be described as using one's strength to assume and maintain a position. For example, lifting the leg and keeping it high in a lifted position without any support. Passive flexibility can be described as using one's body weight or external support to hold and attain a position as in performing Splits. In the sport of Rhythmic gymnastics, a good level of both Active and Passive flexibility is needed. It is interesting to point out that preferred lower limb can be more flexible that non-Preferred lower limb.[15]

Ballet is a rising aesthetic sport that developed during the Italian Renaissance as a theatrical dance form for court entertainment. It is a combination of artistic elements such as music, costume and stage scenery giving it the ability to express emotions and hence making it a living art.[16] Physiological needs of Ballet include muscle strength, endurance, flexibility, agility, power and balance.[17] Ballet corresponds to artistic sports such as Rhythmic Gymnastics, Artistic Gymnastics and ice skating.[18] The core techniques involved in Ballet and Rhythmic Gymnastics are very much alike in various aspects like leaps,

pivots, balances, etc. Various Ballet movements are used as connecting elements, dance steps, body difficulties. Body difficulties use the same nomenclature and are strongly influenced by Ballet movements. Ballet elements being the basis of body techniques of Rhythmic Gymnastics are present in routines according to the analysis conducted for ballet movements in Rhythmic Gymnastics routines in the Olympic cycles of 2013-2016 and 2017-2020.[2] It improves Gymnasts technique, body and apparatus difficulties for a better execution of body movements which are accurate, expressive and in rhythm.

Balance, core muscle endurance and lower limb flexibility stand out to be some of the few essential components that work hand in hand to bring about elegant and graceful movements performed by a Rhythmic Gymnast. The importance of balance, core muscle endurance and

lower limb flexibility in the efficiency of athletic performance directs us to further evaluatethese components in Rhythmic Gymnasts. Ballet and Rhythmic Gymnastics are like stories thatare linked together. They are functionally very similar and they mirror each other. Laffranchi emphasized that Ballet should be practiced in Rhythmic Gymnastics as physical preparationsand artistic execution.[19]Ballet movements using Ballet bars can be incorporated into thetraining of a Rhythmic Gymnast to bring about meticulous and precise body movements.[20] This study thus aims to evaluate balance, core muscle endurance and flexibility of lower limbin Rhythmic Gymnasts and Ballet trained Rhythmic Gymnasts.

AIM

To evaluate balance, core muscle endurance and flexibility of lower limb in RhythmicGymnasts and Ballet trained Rhythmic Gymnasts.

OBJECTIVES

- To assess balance, core muscle endurance and flexibility of lower limb in RhythmicGymnasts.
- To assess balance, core muscle endurance and flexibility of lower limb in Ballet trainedRhythmic Gymnasts.
- To compare the test results of balance, core muscle endurance and flexibility of lower limbin Rhythmic Gymnasts and Ballet trained Rhythmic Gymnasts.

YPOTHESIS

Null hypothesis

Ballet trained Rhythmic Gymnasts do not exhibit better balance, core muscle endurance,flexibility of lower limb than Rhythmic Gymnasts.

Alternate Hypothesis

Ballet trained Rhythmic Gymnasts exhibit better balance, core muscle endurance and flexibilityof lower limb than Rhythmic Gymnasts.

REVIEW OF LITERATURE

Ballet movements in Rhythmic Gymnastics routine: Analysis from the last two code of points.

The purpose of this research was to analyse the Ballet movements in Rhythmic Gymnastics routines in the 2013-2016 and 2017-2020 Olympic cycles, in order to further understand the relationship between Rhythmic Gymnastics and Ballet and compare them in two different Rhythmic Gymnastics Code of Points. This was quantitative research that analysed 24 Rhythmic Gymnastics routines performed at the Rhythmic Gymnastics World Championship (2013 and 2019) recorded and posted at one of the International Gymnastics Federation's official social media websites.

By analysing the Ballet movements in the Rhythmic Gymnastics routines in the Olympic cycles of 2013-2016 and 2017-2020, we concluded that these elements, being the basis of the body technique of Rhythmic Gymnastics, remained present in the routines. Regardless of changes in the Code of Points over the years, Ballet's movements are timeless and must be worked on in Rhythmic Gymnastics.

METHODOLOGY

Type of Study- Cross Sectional Study.

Study Setting – Phoenix Gymnastics Academy, Thane.

Sampling Technique – Purposive Sampling.

Sample Population – Rhythmic Gymnasts and Ballet trained Rhythmic Gymnasts.

Sample Size – (n=30) 15 Rhythmic Gymnasts and 15 Ballet trained Rhythmic Gymnasts.

Assessment Parameters

1) Balance:

Test 1- Balance test in the Arabesque position.Test 2- Balance test in Back-grab position.

Test 3- Balance test in the Heel stretch position.

Test 4- Movement from the Arabesque to the Passé position.

2) Core muscular endurance: McGill's torso muscular endurance test battery.

3) Flexibility: Battery of lower limb flexibility tests of Federation InternationalGymnastics (FIG, 2010)

Analysis – SPSS software (version 24)

Selection criteria -

Inclusion criteria:

a) Rhythmic Gymnasts and Ballet trained Rhythmic Gymnasts.

b) Age Group – 8 to 20 years

Exclusion criteria:

a) Rhythmic Gymnasts who have suffered from any neuro-musculoskeletal injuries in thepast one year.

b) Rhythmic Gymnasts suffering from any acute neuromuscular-skeletal injuries.

Plan of Study

A cross sectional study was done on a targeted population of Rhythmic Gymnasts and ballet trained Rhythmic Gymnasts to evaluate balance, core muscle endurance andflexibility of lower limb and to compare the test results.

Ethical approval was taken by the Institutional Ethics Review Committee and permission from the authorities at Phoenix Gymnastics Academy, Thane was sought by the co-investigators.

The participants who fulfilled the inclusion criteria were selected through purposive sampling technique. Participants were explained about the research, its purpose, duration for which the research is conducted in the language best understood by them and queries were solved. Participants were provided with a participant information sheet and a consent form through which written consent was sought.

Three validated tests for balance, core muscle endurance and flexibility of lower limb were selected. A total of 30 gymnasts were selected out of which 15 were Rhythmic Gymnasts and 15 Ballet trained Rhythmic Gymnasts. Demographic data was collected which included name, age, gender, height, weight and years of experience. The BMI was calculated based on the height and weight and was recorded on the assessment sheet of each participant. The participants were informed about the reasons for performing the tests and the methods of execution. Data collected was coded in an excelsheet and was analysed in the SPSS software version 24.

1) alance Test

For the balance test four tests were selected which aim to evaluate static and dynamic balance. These tests were selected as the balance is tested in positions specific to Rhythmic Gymnasts and has shown high reliability.[23]

Test 1: Balance test in Arabesque position

To perform this test the participants were instructed to extend the leg to 90 degrees, handsby the side of the body. Once the participant assumed the desired position, they had to raise their heel up to the midpoint. The timer was started. They were instructed to maintain this position for as long as possible without losing the balance and the time was recorded.

Fig1.1 Balance test in the Arabesque position

Test 2: Balance test in Back-grab position

The participants were asked to attain the back grab position by raising the active leg upwards and supported by the hands. Once the participants assumed this position, they were asked to raise their heels. The amount of time they could maintain this position was recorded.

Fig1.2 Balance test in back grab position

Test 3: Balance test in Heel stretch position

Participants were instructed to adopt the heel stretch position by supporting the active leg with one arm which was placed above the line of the head with the foot pointed upwards and the other arm extended. They were then asked to raise their heel up to the midpoint for 10 times. On the 10th repetition, the participants were asked to maintain this position. The time for which

they could maintain the position without losing their balance is noted.

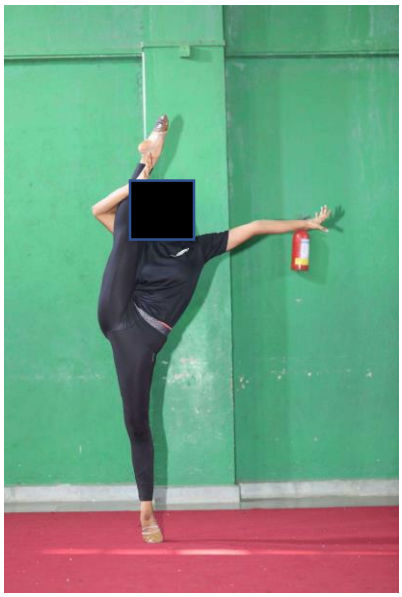


Fig1.3 Balance test in the heel stretch position.

Test 4: Movement from the arabesque position to the passé position

The participant was asked to keep their heel raised and asked to transition from the arabesque position to passé position to forward leg extension to leg extended backwards. The number of repetitions they could perform without losing their balance or falling was noted.

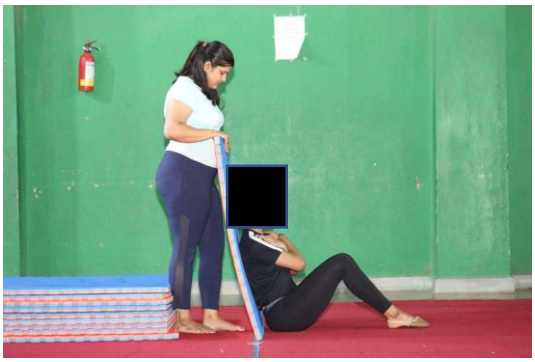
Fig 1.4 Movement from the Arabesque to the passé position

2) McGill's torso muscular endurance test battery:

The participants were tested for three different muscle groups namely, trunk flexors, trunkextensors and the lateral flexors. This test was selected as it showed high reliability coefficient >0.97. [21]

1) Trunk Flexor Endurance Test

For testing the trunk flexors, the Gymnasts were instructed to sit with hips and knees flexed to 90 degrees, with the hips, knees and the second toe aligned with each other. They were then asked to hold arms across the chest, with the palms touching the opposite shoulders. They were instructed to lean against a board which had a 60 degrees incline and to press the shoulders against the board. Participants had to maintain the position after the board was removed by engaging the abdominal muscles to maintain a flat to neutral spine. As soon as the board was removed, the stopwatch was started. The test was terminated as soon as there was any noticeable change in the position of the trunk. The final time was noted.



2.1 (a) Trunk flexor endurance test

2.1(b) Trunk flexor endurance test

2) Trunk Lateral Endurance Test

In this test, participants were asked to lie on their sides with both the legs extended, aligning feet on top of each other or in a

tandem position, lower arm under the body and upper arm on the side. They were given instructions to assume a full side bridge position by elevating thehips off the ground in a straight alignment (i.e., head, neck, torso, hips, and legs). Timer was started. The test was terminated when a noticeable change in the trunk position was observed. The final time was recorded. This test was also performed on the opposite side and the time was recorded.

Fig 2.2 Trunk lateral endurance test (right)

Fig 2.3 Trunk lateral endurance test (left)

3) Trunk Extensor Endurance Test

The starting position required the participants to be prone in such a way that both iliac crests were at the edge of the mats. The weight of the upper body was supported by participants while the lower extremities were stabilised by the co-investigator. Participants were instructed to hold a horizontal, prone position. Stopwatch was started as soon as this position was assumed. Test was terminated once the participants fell below the horizontal.

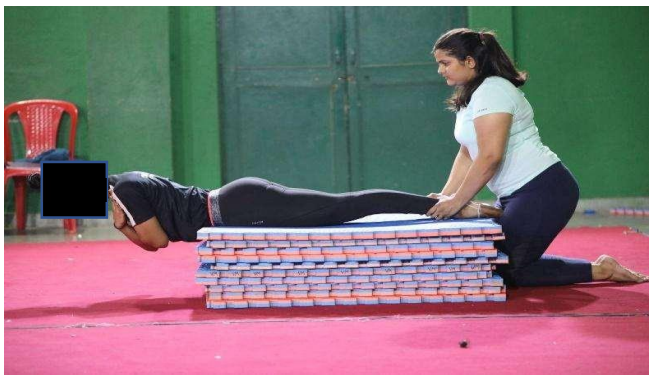


Fig 2.4 Trunk extensor endurance test.

3) Battery of lower limb flexibility tests of Federation International Gymnastics (FIG, 2010)

The battery of lower limb flexibility tests of Federation International Gymnastics (FIG, 2010), aims at evaluating the active and passive lower limb flexibility in the preferred and non- preferred lower limb. It consists of 7 specific Rhythmic Gymnast movements. There are 5 classification values attributed to each movement, referring to the maximum possible range of motion, (0 = very poor, 1 = poor, 2 = average, 3 = good and 4 = excellent).This test was selected as it is specific to the sport of Rhythmic Gymnastics and has high reliability.[15]

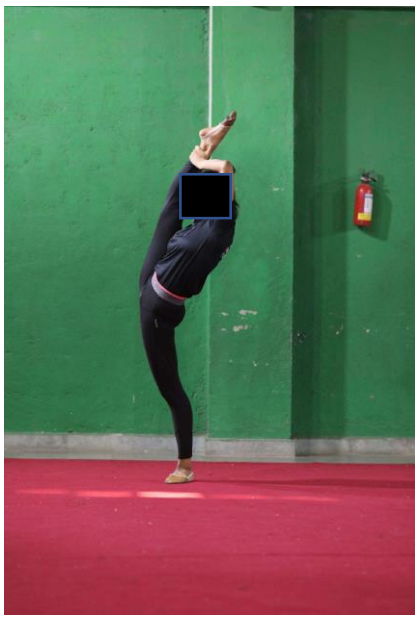


Fig 3.1 Test 01

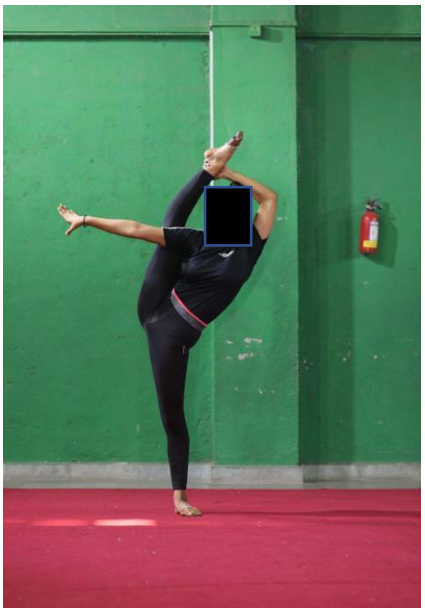


Fig 3.2 Test 02

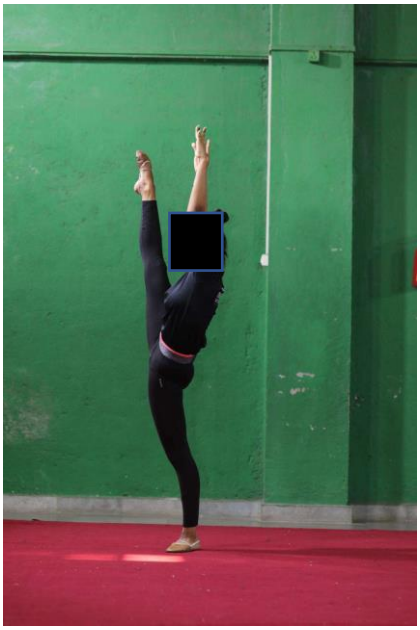


Fig 3.3 Test 03

Fig 3.4 Test 04

Fig 3.5 Test 05

Fig 3.6 Test 06

Fig 3.7 Test 07

STATISTICAL ANALYSIS

Data was analysed using the IBM SPSS Software (Version 24). The data was checked for normality using values of Skewness, Kurtosis. Accordingly appropriate parametric and non- parametric tests were applied.

For normally distributed data Unpaired T test was used.

For data not normally distributed Mann Whitney U Test was used.

RESULTS

Group A: Rhythmic Gymnasts, Group B: Ballet trained Rhythmic Gymnasts

Table 1: DEMOGRAPHIC DATA

Group (A) Rhythmic Gymnasts

Demographic data	(Mean ± Standard deviation)
Age	13 ± 2.20
Height	145.2 ± 17.44
Weight	37.2 ± 10.61
BMI	17.5 ± 3.368
Experience	7.4 ± 2.32

(Group B) Ballet trained Rhythmic Gymnasts

Demographic data	(Mean ± Standard deviation)
Age	13.46 ± 2.41
Height	150.4 ± 11.85
Weight	37.3 ± 7.128
BMI	16.4 ± 1.963
Experience	7.8 ± 1.64

GRAPH.1: Shows baseline values for Group A and Group B

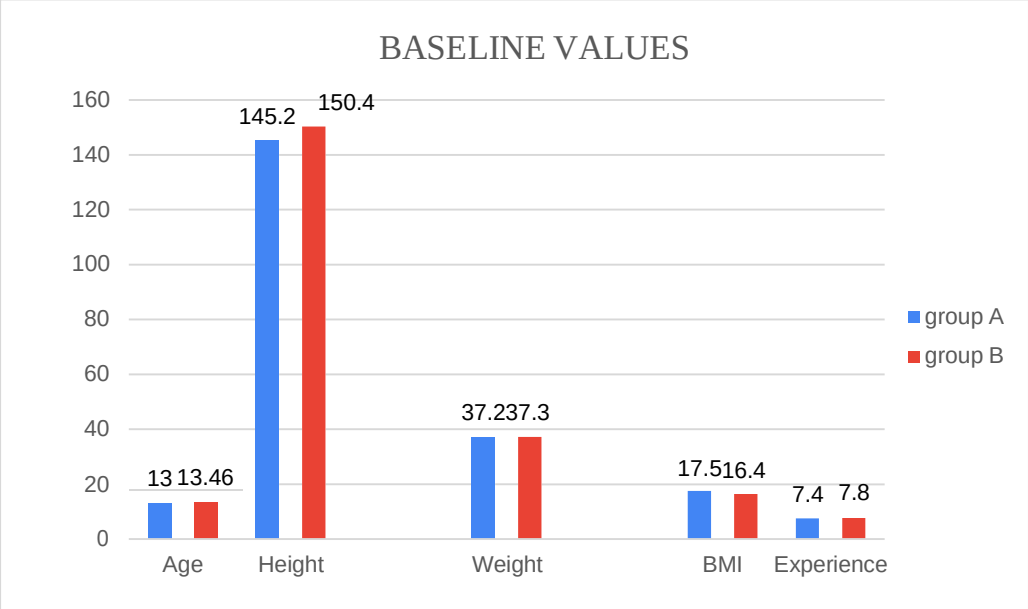
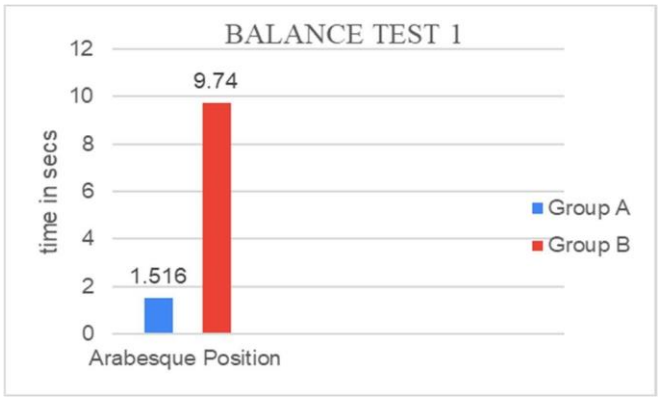


Table 2: BALANCE TEST

Name of the tests	**(Group A) Rhythmic Gymnasts (Mean ± Standard deviation)**	**(Group B) Ballet trained Rhythmic Gymnasts (Mean ± Standard deviation)**	**P value**
Arabesque Position(in secs)	1.516 ± 1.06	9.74 ± 6.39	0.000*
Back-grab Position(in secs)	0.95 ± 0.62	2.55 ± 0.896	0.00*
Heel Stretch Position(in secs)	0.95 ± 0.63	5.83 ± 3.94	0.00*
Movement from the Arabesque to the passe (noof repetitions)	0.33 ± 0.48	2.36 ± 1.91	0.001*

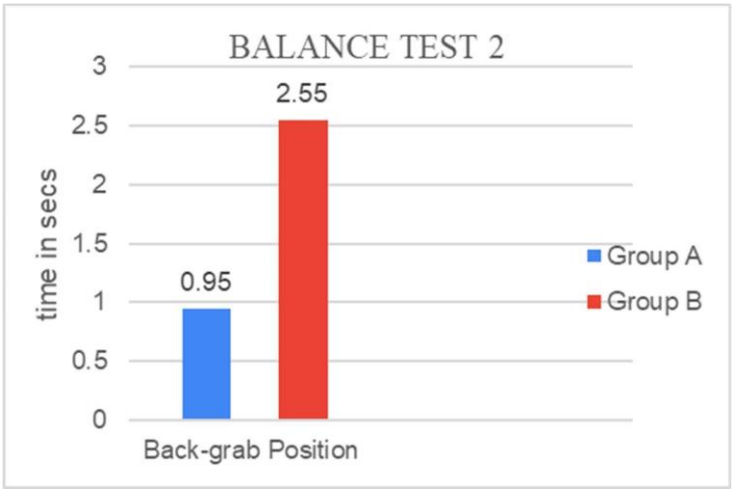
*Defines the significant difference between group A and group B

GRAPH.2.1: Balance test analysis in arabesque position for Group A and Group B



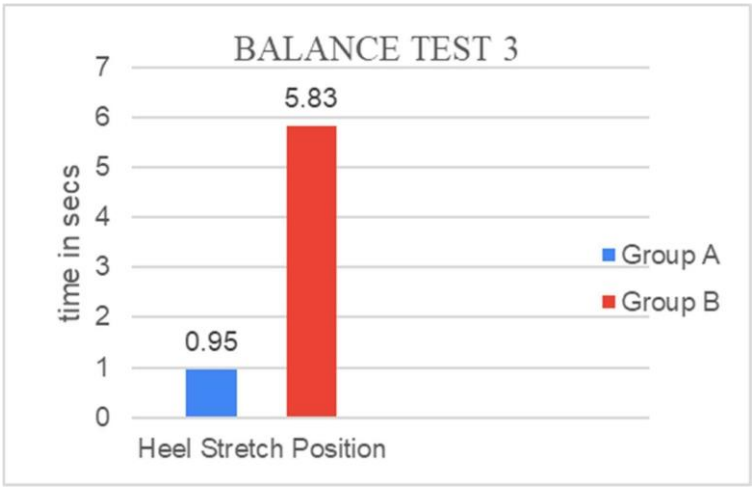
Inference: There was significant difference in balance test – The Arabesque position between Rhythmic Gymnasts and ballet trained Rhythmic Gymnasts with p value being 0.00

GRAPH.2.2: Balance test analysis in back-grab position for Group A and Group B



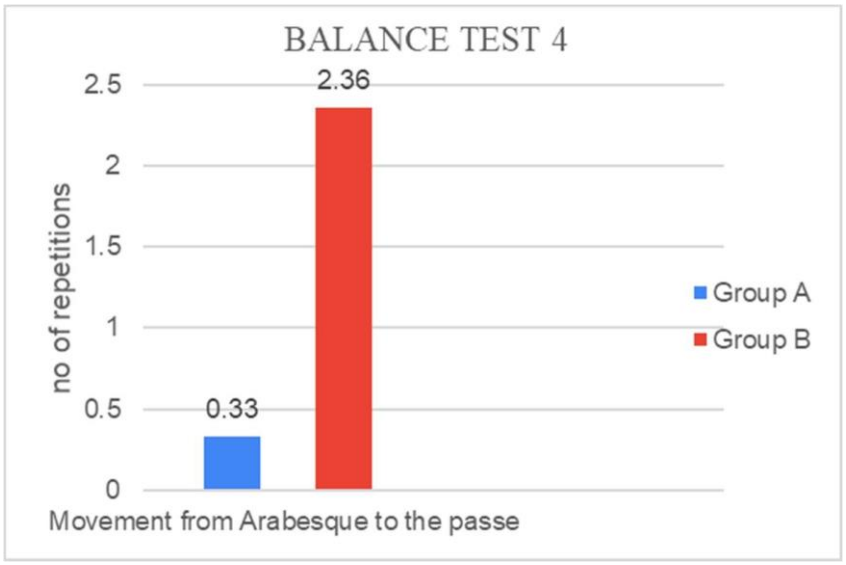
Inference: There was significant difference in balance test- back-grab position between Rhythmic Gymnasts and ballet trained Rhythmic Gymnasts with p value being 0.00

GRAPH.2.3: Balance test analysis in heel stretch position for Group A and Group B



Inference: There was significant difference in balance test - heel stretch position between Rhythmic Gymnasts and ballet trained Rhythmic Gymnasts with p value being 0.00

GRAPH.2.4: Balance test analysis in Movement from the Arabesque to the passé position for Group A and Group B



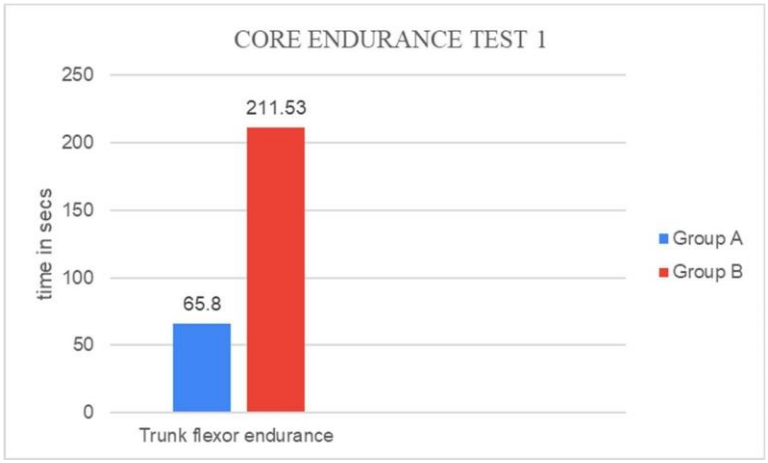
Inference: There was significant difference in balance test - Movement from the Arabesque to the passé between Rhythmic Gymnasts and ballet trained Rhythmic Gymnasts with p valuebeing 0.001

Table 3: CORE ENDURANCE TEST

Name of the tests	(Group A) Rhythmic Gymnasts (Mean ± Standard deviation)	(Group B) Ballet trained Rhythmic Gymnasts (Mean ± Standard deviation)	P value
Trunk flexor endurance test(in secs)	65.8± 22.52	211.53 ± 144.5	0.01*
Trunk lateral endurancetest(right) (in secs)	55.93 ± 21.08	72.93± 16.97	0.022*
Trunk lateral endurancetest(left) (in secs)	53 ± 21.41	81.13± 25.63	0.03*
Trunk extensor endurance test(in secs)	52.73 ± 19.6	111.53 ± 59.36	0.01*

*Defines the significant difference between group A and group B

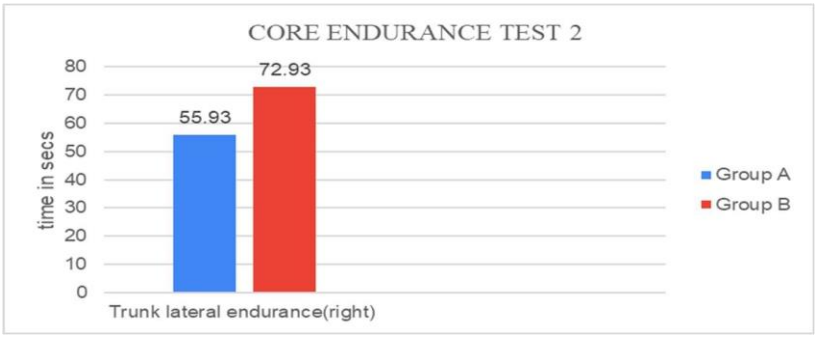
GRAPH.3.1: Core endurance test analysis for trunk flexors between Group A and Group B



Inference: There was significant difference in core endurance test- trunk flexor endurance between Rhythmic Gymnasts and ballet trained Rhythmic Gymnasts with p value being 0.01

GRAPH.3.2: Core endurance test analysis for trunk lateral flexors (right side) between

Group A and Group B

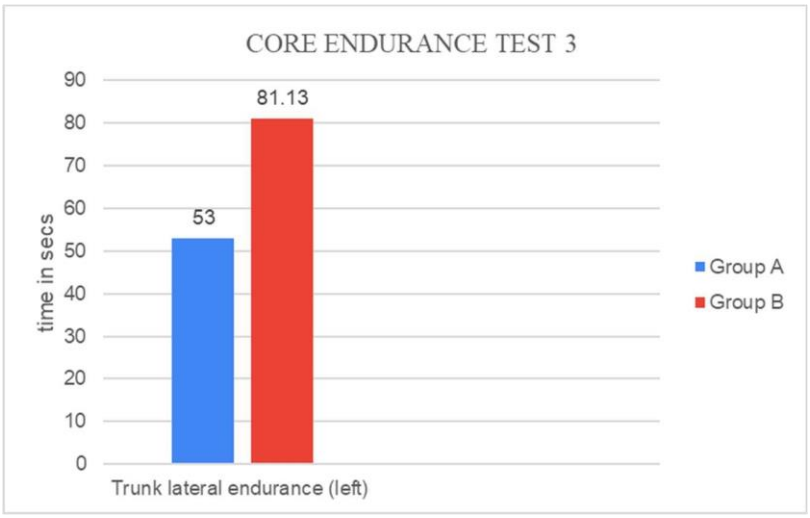


Inference: There was significant difference in core endurance test -trunk lateral endurance (R)

between Rhythmic Gymnasts and ballet trained Rhythmic Gymnasts with p value being 0.022

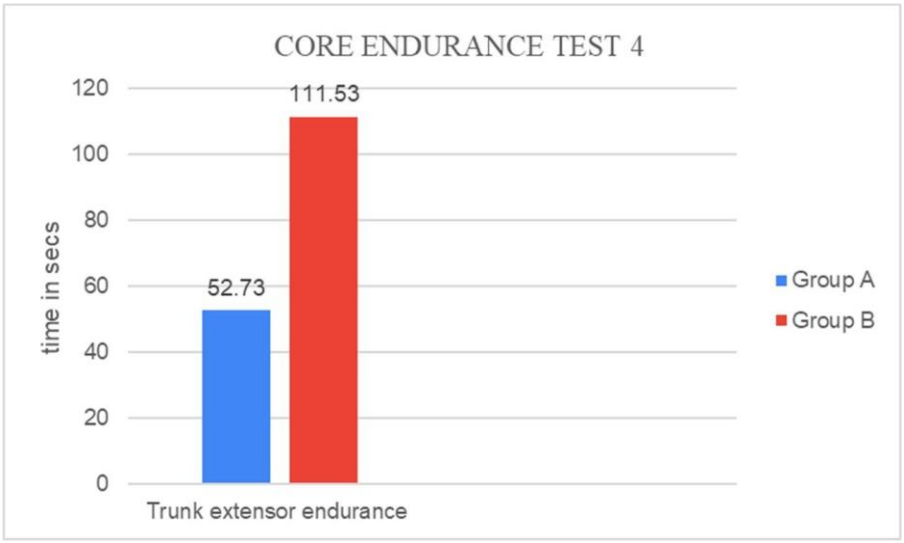
GRAPH.3.3: Core endurance test analysis for trunk lateral flexors (left side) between

Group A and Group B



Inference: There was significant difference in core endurance test -trunk lateral endurance (R) between Rhythmic Gymnasts and ballet trained Rhythmic Gymnasts with p value being 0.03

GRAPH.3.4: Core endurance test analysis for trunk extensor between Group A and Group B



Inference: There was significant difference in core endurance test -trunk extensor endurance between Rhythmic Gymnasts and ballet trained Rhythmic Gymnasts with p value being 0.01

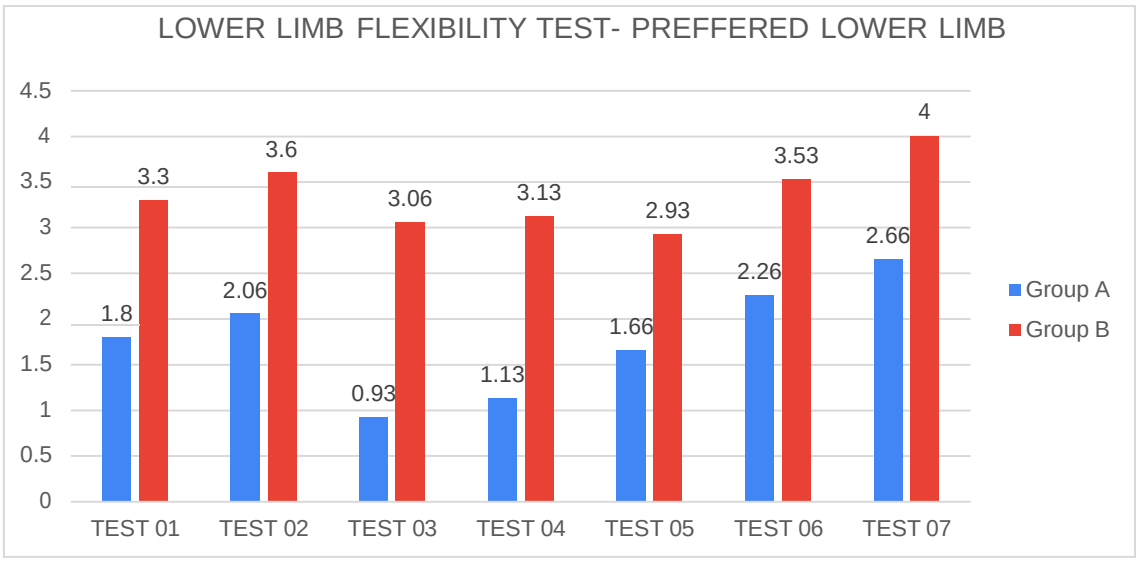
TABLE 4.1: FLEXIBILITY TEST– (Preferred Lower Limb)

Name of the test – (Preferred Lower Limb)	(Group A) Rhythmic Gymnasts (Mean ± Standard deviation)	(Group B) Ballet trained Rhythmic Gymnasts) (Mean ± Standard deviation)	P value
Test01--Supported lower limb – Hold to thefront	1.8 ± 0.77	3.3±0.61	0.00*
Test02-Supported lower limb – Hold to the side	31 ± 0.79	3.6 ± 0.61	0.00*
Test03-Unsupported lower limb – Hold to the front	0.93 ±1.09	3.06 ± 0.96	0.00*

Test04-Unsupported lower limb – Hold to theside	1.13 ± 0.99	3.13 ± 0.83	0.00*
Test05-Supported lower limb – Hold to the rear	1.66 ± 1.63	2.93 ± 0.88	0.010*
Test06-Unsupported lower limb – Hold to therear-Penché	2.26 ± 1.03	3.53 ± 0.63	0.011*
Test07-Split on two benches	2.66 ±1.23	4 ± 0	0.00*

*Defines the significant difference between group A and group B

GRAPH.4.1: Lower limb flexibility analysis for preferred lower limb between Group A and Group B



Key: Test 01-Supported lower limb – Hold to the front, Test 02-Supported lower limb – Hold to the side, Test 03-Unsupported lower limb – Hold to the front, Test 04-Unsupported lower limb – Hold to the side, Test 05-Supported lower limb – Hold to the rear, Test 06-Unsupported lower limb – Hold to the rear, Test 07-Split on two benches.

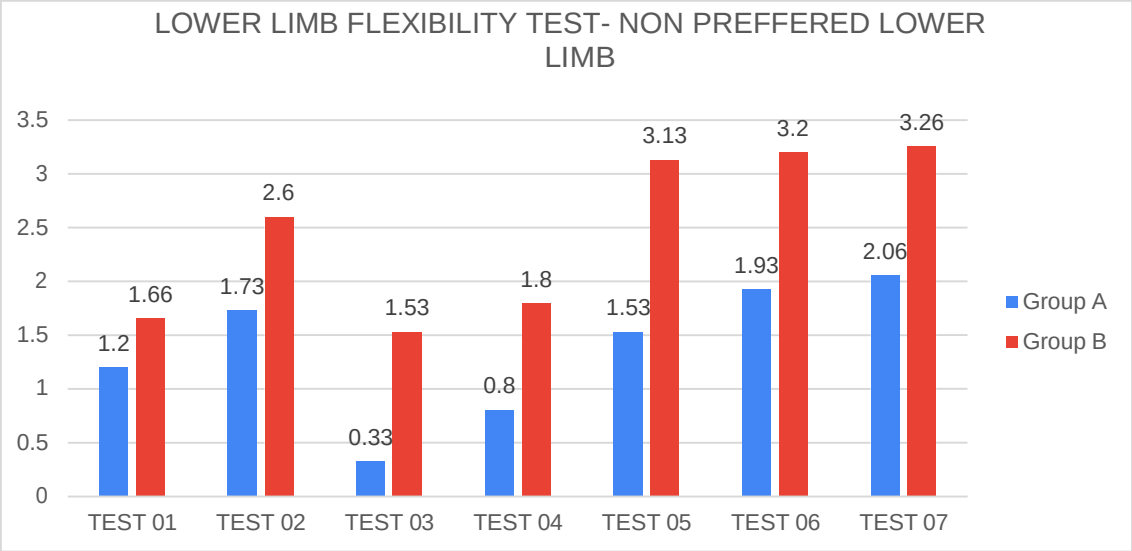
Inference: There was a significant difference in the battery of LL flexibility tests of Federation International Gymnastics (FIG, 2010) in Rhythmic Gymnasts and ballet trained RhythmicGymnasts.

TABLE 4.2: FLEXIBILITY TEST- (Non-Preferred Lower Limb)

Name of the test – (Non-Preferred Lower Limb)	(Group A) Rhythmic Gymnasts (Mean ± Standard deviation)	(Group B) Ballet trained Rhythmic Gymnasts (Mean± Standard deviation)	P value
Test01-Supported lower limb – Hold to the front	1.2 ± 1.01	1.66 ± 0.72	0.158
Test 02-Supported lower limb – Hold to the side	1.73 ± 0.70	2.6 ± 0.82	0.05*
Test 03-Unsupported lower limb – Hold tothe front	0.33 ± 0.72	1.53 ± 0.63	0.00*
Test04-Unsupported lower limb – Hold tothe side	0.8 ± 0.77	1.8 ± 0.56	0.00*
Test05-Supported lower limb – Hold to therear	1.53 ± 1.18	3.13 ± 1.12	0.01*
Test06-Unsupported lower limb – Hold tothe rear- Penché	1.93 ± 0.88	3.2 ± 0.56	0.00*
Test07-Split on two benches	2.06 ±1.03	3.26 ± 0.79	0.01*

*Defines the significant difference between group A and group B

GRAPH.4.2: Lower limb flexibility analysis for non-preferred lower limb between Group A and Group B



Key: Test 01-Supported lower limb – Hold to the front, Test 02-Supported lower limb – Hold to the side, Test 03-Unsupported lower limb – Hold to the front, Test 04-Unsupported lower limb – Hold to the side, Test 05-Supported lower limb – Hold to the rear, Test 06-Unsupported lower limb – Hold to the rear, Test 07-Split on two benches.

Inference: There was a significant difference in the battery of LL flexibility tests of Federation International Gymnastics (FIG, 2010) in Tests 2- Test 07 between Rhythmic Gymnasts and ballet trained Rhythmic Gymnasts.

There was no significant difference in the battery of LL flexibility tests of Federation International Gymnastics (FIG, 2010) in Test 01-Supported lower limb – Hold to the front with p value being 0.158

DISCUSSION

The purpose of this study was to evaluate balance, core muscle endurance and flexibility of lower limb in Rhythmic Gymnasts and Ballet trained Rhythmic Gymnasts. The objectives were to evaluate the test results in Rhythmic Gymnasts and Ballet trained Rhythmic Gymnasts and compare the test results between the two. To the best of our knowledge, this is the first study to evaluate balance, core muscle endurance and flexibility of lower limb in Rhythmic Gymnasts and Ballet trained Rhythmic Gymnasts. Out of 30 participants 15 were Rhythmic Gymnastsand 15 were Ballet trained Rhythmic Gymnasts. The results of the tests showed a significant difference in all 3 parameters of Group A (Rhythmic Gymnasts) and Group B (Ballet trained Rhythmic Gymnasts)

The Postural control system is largely dependent on the interaction of the Vestibular, visualand the somatosensory systems. Postural stability is essential in Rhythmic Gymnasts to hold balances, pirouettes and the jumps.[22]The ability of the gymnasts to hold well defined positions and maintain them allows the Judges to assess their difficulties and grade them. The Balance

tests 01, 02, 03 aims at evaluating the static balance and test 04 at the dynamic balance. Test01 balance test in Arabesque position Group A {1.516 ± 1.06, p=0.000} and Group B {9.74 ±6.39, p=0.0}, test02 balance test in Back-grab position Group A {0.95 ± 0.62, p=0.000} and Group B {2.55 ± 0.896, p=0.00} , test03 balance test in Heel stretch position Group A {0.95 ± 0.63, p=0.000} and Group B {5.83 ± 3.94, p=0.00}and test04 movement from the Arabesqueto the Passe Group A {0.33 ± 0.48, p=0.000} and Group B {2.36 ± 1.91, p=0.01} showed far more significant difference in group A (Rhythmic Gymnasts) and group B (Ballet trained Rhythmic Gymnasts) with higher mean scores in Group B. Ballet dancers are better in performing static and dynamic balance than untrained athletes.[13] Hence we can say that this can be a contributing factor for better Balance in Ballet trained Rhythmic Gymnasts. In gymnastics to perform a maximum number of strength elements in a competition routine, a high-level core muscle endurance is required. This occurs when a relatively high power output is maintained for 30-60 seconds.[17] This could be, for example, in a series of jumps. In this study, there was a significant Difference in group A (Rhythmic Gymnasts) and group B (Ballet trained Rhythmic Gymnasts) with higher mean scores in Group B. For core flexor endurance group, A {65.8± 22.52, p=0.001} and group B {211.53 ± 144.5, p=0.01}. For core extensor endurance, group A {52.73 ± 19.6, p=0.01} and group B {111.53 ± 59.36, p=0.001}, For trunk lateral endurance (right) Group A {55.93 ± 21.08, p=0.022} and Group B {72.93± 16.97, p=0.022}. For trunk lateral endurance (left) Group A {53 ± 21.41, p=0.03} and Group B
{81.13± 25.63, p=0.03}. Research suggests that Ballet dancers have higher endurance levels as to the demand of their dance. This could be a contributing factor for better core muscle endurance in Ballet trained Rhythmic Gymnasts. A strong core allows complete transfer offorces from the upper and lower extremity through the trunk (core) [9] . Therefore, an adequate development of core muscle endurance can increase performance by helping in execution and maintaining the technical elements.

Flexibility is one of the main motor skills of Rhythmic Gymnasts. Active flexibility can be described as using one's strength to assume and maintain a position for example lifting the leg and keeping it high in a lifted position without any support. Passive flexibility can be described as using one's own body weight or external support to hold and attain a position.[17]The battery of lower limb flexibility tests of Federation International Gymnastics (FIG, 2010) aims to assess the Active and Passive flexibility levels of the lower Limb elements that the Gymnastsregularly use in their practice. In the flexibility tests of Preferred lower limb (test01, test02, test03, test04, test05, test06, test07) and non-preferred lower limb (test02, test03, test04, test05, test06, test07) there was a significant difference in group A (Rhythmic Gymnasts) and groupB (Ballet trained Rhythmic Gymnasts) with significantly higher mean scores in Group B. This could be due to Ballet dancers having significantly higher flexibility. However, test 01 of non- preferred lower limb showed no significant difference group A {1.2 ± 1.01, p=0.158} and group B {1.2 ± 1.01, p=0.158}. This is due to the Gymnasts having more flexibility in their preferred lower limb than their non preferred lower limb. [15] Furthermore, group B (Ballet trained Rhythmic Gymnast) presented with higher mean scores in comparing the preferred and non-preferred lower limb than group A (Rhythmic Gymnasts).

CONCLUSION

From this study we conclude that Ballet trained Rhythmic Gymnasts exhibited far better balance, core muscle endurance and flexibility of lower limb than Rhythmic Gymnasts. Hence, incorporating Ballet training along with skill-based training can be

beneficial for the Gymnasts.

REFERENCES

1) Caine DJ, Russell K, Lim L, editors. Handbook of sports medicine and science: gymnastics. John Wiley & Sons; 2013 Jul 18.; page 3/186

2) Nabanete dos Reis Furtado L, de Toledo E, Fernandes Antualpa K, Carbinatto MV. BALLET MOVEMENTS IN RHYTHMIC GYMNASTICS ROUTINES: AN ANALYSIS FROM THE LAST TWO CODE OF POINTS (2013-2016 and 2017-2020). Science of Gymnastics Journal. 2020 Sep 1;12(3).

3) Laffranchi, B. (2001). Treinamento Desportivo Aplicado à Ginástica Rítmica.Londrina: Unopar

4) Bobo-Arce M, Méndez Rial B. Determinants of competitive performance in rhythmic gymnastics: a review.

5) Rutkauskaitė R, Skarbalius A. Interaction of training and performance of 13-14-year- old athletes in rhythmic gymnastics. Ugdymas. Kūno kultūra. Sportas. 2011(3):29-36.

6) Bressel, E., Yonker, J. C., Kras, J., & Heath, E. M. (2007). Comparison of static and dynamic balance in female collegiate soccer, basketball, and gymnastics athletes. Journal of Athletic Training, 42(1), 42–6.

7) Duarte M, Freitas SM. Revisão sobre posturografia baseada em plataforma de força para avaliação do equilíbrio. Brazilian Journal of Physical Therapy. 2010;14:183-92.

8) Shahheidari S, Norasteh A, Mohebbi H. Comparison of balance control in female athletes in different sports. Medicina dello Sport. 2012 Mar 1;65(1):37-47.

9) Akuthota V, Nadler SF. Core strengthening. Archives of physical medicine and rehabilitation. 2004 Mar 1;85:86-92.

10) Schärer C, Tacchelli L, Göpfert B, Gross M, Lüthy F, Taube W, Hübner K. Specific eccentric–isokinetic cluster training improves static strength elements on rings for elite gymnasts. International Journal of Environmental Research and Public Health. 2019 Jan;16(22):4571.

11) Koutedakis Y, Jamurtas A. The dancer as a performing athlete. Sports medicine. 2004 Aug;34(10):651-61.

12) Kibler WB, Press J, Sciascia A. The role of core stability in athletic function. Sports medicine. 2006 Mar;36(3):189-98.

13) Anderson K, Behm DG. The impact of instability resistance training on balance and stability. Sports medicine. 2005 Jan;35(1):43-53..

14) Long KL, Milidonis MK, Wildermuth VL, Kruse AN, Parham UT. The Impact of Dance-Specific Neuromuscular Conditioning and Injury Prevention Training on Motor Control, Stability, Balance, Function and Injury in Professional Ballet Dancers: AMixed-Methods Quasi-Experimental Study. International journal of sports physical therapy. 2021;16(2):404. 2006 Mar;36(3):189-98.

15) Batista A, Garganta R, Ávila-Carvalho L. Flexibility and functional asymmetry inrhythmic gymnastics. Athens Journal of Sports. 2019;6(2):77-94.

16) Schimmelpfennig J. 10 Ballet. A Handbook of Cultural Economics. 2003:85; chapter3, page 85 to 90.

17) Twitchett EA, Koutedakis Y, Wyon MA. Physiological fitness and professional classical ballet performance: a brief review. The Journal of Strength & Conditioning Research. 2009 Dec 1; 23(9):2732-40; volume 23, issue 9, page 2732 - 2740.

18) Twitchett E. Physiological demands of performance in Classical Ballet and their relationships with injury and aesthetic components; page 15/216.

19) Laffranchi, B. (2001). Treinamento Desportivo Aplicado à Ginástica Rítmica.Londrina: Unopar

20) Fédération Internationale de Gymnastique (FIG). (2019). Age Group Development and Competition Program. Retrieved 11/08/2020.

21) Dejanovic A, Cambridge ED, McGill S. Isometric torso muscle endurance profiles in adolescents aged 15–18: Normative values for age and gender differences. Annals of human biology. 2014 Mar 1;41(2):153-8.

22) Massion, J. (1944, december 1). Postural control system. PubMed. Retrieved April 16, 2022

23) Palomares BR, Palomares EM, Uchôa FN, Andrade RD, Deana NF, Alves N. Effectiveness of the conjugate influence method in improving static and dynamic balance in rhythmic gymnastics gymnasts. Journal of Physical Education and Sport. 2019 Jul 1; 19:1407-17.

ANNEXURES

Annexure A: Participant information sheet

Research Title: Evaluation of Balance, Core Muscle Endurance and Flexibility of Lower Limbin Rhythmic Gymnasts and Ballet trained Rhythmic Gymnasts: A Cross Sectional Study.

Introduction:

We, the interns of MGM School of Physiotherapy, are conducting research on 'Evaluation of balance, core muscle endurance and flexibility of lower limb in Rhythmic Gymnasts and Ballet trained Rhythmic Gymnasts: A cross sectional study'. The aim of this research is to evaluate the influence of ballet on the aspects of balance, core muscle endurance and flexibility of the lower extremity for which we will be conducting certain tests.

Purpose of the study:

Rhythmic gymnastics has a high demand of balance, core muscle endurance and flexibility of lower limbs. Similarly, ballet also requires equal amounts of balance, core muscle endurance and flexibility of the lower limbs. Therefore, we intend to explore the influence of ballet training on the aspects mentioned above.

Study procedure to be followed:

1. Participants would be selected by purposive sampling technique and would be screened for inclusion and exclusion criteria.
2. Informed consent would be taken from the participants.
3. Demographic details of the participants would be taken.
4. The participants would further be explained about evaluation tests and the procedure to perform them tests for balance (tests in Arabesque, Back Grab and Heel stretch position and Movement from the Arabesque to the Passé position), core muscle endurance (McGill's torso muscle endurance test battery) and flexibility (battery of lower limb test, FIG,2010).

Confidentiality:

All study records will be kept confidential at all times. Your identity will not be revealed inthese publication

Contact for further information:

Thank you for taking time to read the information about this study.

Before you sign this document, you should ask questions about anything that you do not understand. The study staff will answer your questions before, during and after the study. Ifyou have any questions regarding the study, possible effects or possible research related injuries, kindly contact any of the following.

Avani Dixit +91 9022341642

Shivani Chavan +91 98193 09823

Neha Damle +91 8779626404

Mubarak Desai +91 84528 65159

Vidhi Desai +91 88794 38537

If you have any questions about your rights as a research participant or complaints regardingthe research study, you may contact Dr. Anisha Gulati (PT), MGM School of Physiotherapy,at +91 9773859832 during office hours.

Annexure B: Consent form

Research Title: Evaluation of Balance, Core muscle Endurance and Flexibility of Lower Limbin Rhythmic Gymnasts and Ballet trained Rhythmic Gymnasts: A Cross Sectional Study.

Participant's details:

Name	
Date of birth / Age	

1. I voluntarily agree to participate in this research study.

2. I have understood the information given in this informed consent document for this study titled "Evaluation of balance, core muscle endurance and flexibility of lower limb in Rhythmic Gymnasts and Ballet trained Rhythmic Gymnasts."

3. I understand that even if I agree to participate now, I can withdraw at any time or refuse to answer any question without any consequences of any kind.

4. I have had the purpose and nature of the study explained to me and I have had the opportunity to ask questions about the study.

5. I understand that I will not benefit directly or indirectly from participating in this research.

6. I understand that any information recorded in the investigation will remain confidential and no information that identifies me will be made publicly available.

7. I understand that I am free to contact any of the people involved in the research to seek further clarification and information.

Academy Director ---------- Signature ----------

Annexure C: Assessment sheet

Demographic details:

Participant ID	
Date of birth /Age	
Height (cm)	
Weight (kg)	
BMI	
Experience (in years)	
Ballet Trained	

1) Balance tests:

Sr. No.	Name of the test	Time to complete
1.	Balance test in the Arabesque position	
2.	Balance test in the Back-grab position	
3.	Balance test in the Heel stretch position	

4.	Movement from the arabesque to the passé position.	No. of repetitions

2) McGill's torso muscular endurance test:

Sr. No.	Muscle group tested	Time to complete
1.	Trunk flexor endurance test	
2.	Trunk lateral endurance test (right)	
3.	Trunk lateral endurance test (left)	
4.	Trunk extensor endurance test	

3) Battery of lower limb flexibility tests of Federation InternationalGymnastics (FIG, 2010)

Sr. No.	Name of the test	Grade (right)	Grade (left)
1.	Supported lower limb hold to the front		
2.	Supported lower limb hold to the side		
3.	Unsupported lower limb hold to thefront		
4.	Unsupported lower limb hold to theside		
5.	Supported lower limb hold to the rear		
6.	Unsupported lower limb hold to therear-Penché		
7.	Splits on two benches		