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The Influence of Rigorous Training on Physical Growth Between Ages 14-17 among Professional and Non-Professional Gymnasts

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Abstract

The main aim of this study was to determine the influence of rigorous training on physical growth (PG) between age 14-17 among professional and non-professional gymnasts. The study included two groups; 40 professional and 40 non-professional male Artistic gymnasts. The mean difference between both groups shows that the increase in height of professional gymnasts after intervention is less than that of non-professional gymnasts. Professionals in pre-test and post-test which indicates mean and SD scores was found 159.31 ±9.85 in pre-test and 159.94±9.86 in post-test along with Mean % Dif. (0.63) in both tests and p <0.001 indicate that the difference is statistically significant in both pre & post-tests. Overall results show that PG of male artistic gymnasts (age 14-17 years old) was more negatively affected by RT in professional gymnasts as compare to non-professional groups.

Keywords: Artistic Gymnastics, International, Federation, Growth, Training

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Title

The Influence of Rigorous Training on Physical Growth Between Ages 14-17 among Professional and Non-Professional Gymnasts

Abstract

The main aim of this study was to determine the influence of rigorous training on physical growth (PG) between age 14-17 among professional and non-professional gymnasts. The study included two groups; 40 professional and 40 non-professional male Artistic gymnasts. The mean difference between both groups shows that the increase in height of professional gymnasts after intervention is less than that of non-professional gymnasts. Professionals in pre-test and post-test which indicates mean and SD scores was found 159.31 ±9.85 in pre-test and 159.94±9.86 in post-test along with Mean % Dif. (0.63) in both tests and p <0.001 indicate that the difference is statistically significant in both pre & post-tests. Overall results show that PG of male artistic gymnasts (age 14-17 years old) was more negatively affected by RT in professional gymnasts as compare to non-professional groups.

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Keywords:

Artistic Gymnastics, International, Federation, Growth, Training

Contents

Introduction

Physical fitness and growth are essential aspects of human well-being that contribute to overall health and quality of life. They are interconnected and play a significant role in an individual's physical, mental, and social development. Numerous studies (Garcia et al., 2023) indicate that physical fitness and growth are closely tied to physical activity. The World Health

Organization (WHO) claims that physical exercise helps to avoid chronic illnesses including cardiovascular disease, diabetes, and obesity (WHO, 2020). Sports and physical exercise both serve important roles in improving health and well-being, building social relationships, and cultivating a sense of accomplishment. While the players in the sports exertion keep themselves physically and mentally intertwined, they also make the followership enjoy it. Playing well is vital to sensation in sports that cannot be achieved without excellent training. Athletes borrow good training to improve their playing process and keep themselves fit (Berryman et al., 2019).

Gymnastics is a physically demanding sport that requires participants to complete sophisticated and challenging sequences that incorporate aspects of strength, flexibility, power, balance, and coordination. Gymnastics may be linked to prehistoric times when it was used in sports and warfare (Tayne et al., 2021). Gymnasts are athletes who push the limits of human physical capabilities by defying gravity and performing gravity-defying moves with extraordinary control and technique (Kant, 2011). The movement of the body from beginning to end may be thoroughly observed in AG. Strength, Balance, Coordination, Flexibility, and Agility are visible. When viewed scientifically, it depicts the whole biomechanical action. The complete biomechanical law is engaged in the player's movement from the front role to the finish of the game. There are six events included in the AG which are; floor exercise, vaulting horse, parallel bar, pommel horse, still rings, and horizontal bar.

Regarding body movement (BM), Hsu and Valentova (2020) indicate that physical exercise is based on BM that needs energy expenditure. Similarly, Tao and Li (2023) reported that sometimes physical activity and body movement involve high-intensity exercises that are intended to enhance strength, endurance, flexibility, and overall fitness. Athletes, fitness enthusiasts, and professionals in a variety of sports and athletic professions frequently use rigorous training. Although gymnastics is expected to increase an athlete's personality in the same way that other sports enhance a person's personality, nowadays in Gymnastics, it is seen that the athletes who participate in training from the beginning, as they get older, as they move towards the peak level of Gymnastics; their physical growth starts to stagnate. This difference is evident in their parents and players. Additionally, Reaboi (2023) concluded that, if the difference regarding physical growth is due to rigorous training (RT), then we must consider it because athletes come to sports to develop their health and their personality.

Hypotheses

1. There is no significant effect of rigorous training on the height, weight, and body movement in male professional and non-professional gymnasts in Artistic Gymnastics.
2. There is a significant effect of rigorous training on the height and weight of male professional and non-professional gymnasts in Artistic Gymnastics.
3. There is a significant effect of rigorous training on the body movement of male professional and non-professional gymnasts in Artistic Gymnastics.

Research Objective

1. To analyze the effects of rigorous training on the height and weight of male professional and non-professional gymnasts in Artistic Gymnastics.
2. To determine the effects of rigorous training on body movements of floor elements in male professional and non-professional gymnasts in Artistic Gymnastics.

Gap analysis

Georgopoulos et al. (2012) aim of this study was to determine the impact of intensive training on adult final height in elite female rhythmic (RG) and artistic gymnastics (AG). In both elite female RG and AG, genetic predisposition to final height was not disrupted and remained the main force of growth. Although in elite RG genetic predisposition for growth was fully preserved, in elite female AG final adult height falls shorter than the genetically determined target height, though within the standard error of prediction. Therefore, the author analyzed the effects of rigorous training on physical growth and body mobility in children aged 14-17 years through this study. Because the growth rate in children of this age (14-17 years) is much higher than in adolescence and young adulthood.

Literature Review

Sport is concerning the exertion of the body in which the body is exercised according to its aptitude. Playing well is vital to sensation in sports that cannot be achieved without excellent training. Athletes borrow good training to get better in their playing process and keep themselves fit (Makepeace & Young, 2021). As part of sports, physical activity is useful for improving the capacity of mental health. In addition, a study was

conducted to find out whether physical activities at different times can really be helpful in reducing mental pressure (Aguilar-Raab et al., 2021).

Sports Training

Song (2022) reported that the success or failure of any game depends on its level of training which includes technical, physical, tactical, and physiological training of athletes. The results of the study indicated that, if technical and physical factors are left out, players can be exposed to a variety of setbacks that can cause them to fail to achieve their goals. Walsh (2018) indicated that there is a limit to the amount of training that can be done in any game on a regular basis that builds the energy and immunity in an athlete's body. Training with more rest and less intensity reduces the strength of the athlete which is considered necessary for high-intensity exercise which helps to make high-intensity training perfect. If we continue with high-intensity training, the disadvantages outweigh the benefits (Mohamed et al., 2021).

Rigorous Training

A challenging and intensive workout plan that presses athletes to their limitless potential is referred to as rigorous training. It is systematic and controlled training, sometimes involving high-intensity exercises that are intended to enhance strength, endurance, flexibility, and overall fitness. To compare the eccentric overload training of Unilateral vs. Bilateral training with the use of inertial devices when using rigorous skill training or fitness training. The results indicated that both groups showed the best improvement without any change (Núñez et al., 2018). In recent times, it has been observed that the use of high-intensity interval training in sports training is increasing. A study of related literature indicates that guidelines and their advantages and disadvantages have been overlooked. This helps to eliminate the athlete's chronic illness or a situation that has become very complicated. At the same time, this training does not have any negative effects on human memory (Hsieh et al., 2020).

Artistic Gymnastics

Boyle (2022) indicated that there are different kinds of gymnastics including AG, rhythmic gymnastics, trampoline gymnastics, acrobatic gymnastics, and aerobic gymnastics. Arts and humanities scholarship has generally ignored it, with sports history giving analyses of certain gymnastic leaders or regional or national practices. Most current research comes from the field of sports science and focuses on biomechanics, difficulties related to PG, nutrition, eating disorders, and sports psychology. Artistic gymnasts often undergo comprehensive training programs that incorporate strength and conditioning exercises, flexibility training, balance drills, and aerobic conditioning to develop and enhance these fitness components. Tailored coaching and guidance are essential to ensure that young gymnasts progress safely and effectively in their pursuit of excellence in rhythmic and AG.

Physical Growth

PG is a fundamental aspect of human development that occurs from infancy through childhood, adolescence, and into adulthood. Here are some key points about PG.

According to (Silverman & Deuster, 2014), physical growth refers to the process by which an organism, typically a human, increases in size and develops physically over time. This process involves changes in height, weight, body composition, and the development of various bodily systems and structures including musculoskeletal, cardiovascular, metabolic, immunologic, and cognitive growth. It's important to note that physical growth is a dynamic process that occurs throughout the lifespan. While growth is most rapid during childhood and adolescence, it continues into early adulthood, albeit at a slower rate. After a certain point, usually around the late teens or early twenties, growth plates in the bones close, and further increases in height are limited. Additionally, researchers (Chen et al., 2022) have also identified factors of PG such as genetics, nutrition, overall health, and lifestyle choices all influence the rate and extent of PG in individuals. Proper healthcare, a balanced diet, and a healthy lifestyle are key factors in ensuring optimal PG and development. In this study, the researcher has tried to know how RT affects PG, particularly the musculoskeletal, cardiovascular, metabolic, immunologic, and cognitive growth of children aged between 14 and 17, and its effects on their BM (Uraimov, 2022).

Methodology

Study Design

The study under observation was conducted through a Randomized Control Trial (RCT) research design. The RCT data collection methodology was used to collect data for this study. Afterward, the data were collected from participating gymnasts who volunteered for this study. The process of data collection consisted of three stages; 1) Before the intervention stage; 2) During the intervention stage and 3) After the intervention stage.

Study setting

Artistic gymnastic (AG) *is* a type that complies with the FIG codes and one apparatus floor exercise used in this study. In order to perform such physical movements on the gymnastics apparatus, 4-AGs were selected in Multan and Lahore which are large divisions of Pakistan from where 80 gymnasts participated in this study to assess the characteristics of their strength, agility, balance, coordination, and flexibility through intervention.

Population

Participants (N= 225) gymnasts were registered in these clubs whose ages were from 7 to 26 years. Four gymnastics clubs were randomly selected from the Lahore and Multan divisions from which the participants volunteered for this study.

Table 1

Total Population of Study

Sr. #	Gymnasts Categories	Male Gymnasts (age 7-26)
1	Professional	80
2	Non- Professional	133
	Total	225

Table 1 shows the population of this study which was divided into two categories i.e. professional (80) and non-professional (133) gymnasts from 4-selected artistic gymnastics who were 7-26 years old.

Target Population

Table 2

Age-wise Population of Study

Sr. #	Gymnasts Categories	14-15 Age	16-17 Age	Total
1	Professional	45	40	85
2	Non- Professional	40	22	62
	Total	85	62	147

Table 2 shows that, according to the inclusion criteria of this study, professional and non-professional gymnasts between the ages of 14 to 17 were to be included in the study as the targeted population. The researcher sorted 147 out of 225 gymnasts between the ages of 14 to 17, in line with the requirement of this study, which included 85 professional and 62 non-professional gymnasts as shown in the above table.

Sampling

A convenient Sampling Technique was used for this study. Convenient sampling is a procedure of selecting readily and easily available participants. The number of clubs of AG in Pakistan is surprisingly low; for this reason, it was a challenge to select gymnasts of the specific age of (14-17 years old) from their respective clubs.

Table 3

Sample Size of Professional and Non-Professional Gymnasts

Sr. #	Gymnasts Categories	Total Population (14-17 Age)	Sample (14-17 Age)	Sample (14-17 Age)	Total Sample Size
1	Professional	85	20	20	40
2	Non- Professional	62	20	20	40
	Total	147	40	40	80

Table 3 shows the total sample size and population with respect to their professional and non-professional categories in which 40 professionals and 40 non-professionals were calculated.

Data collection procedure

The data were collected from gymnasts who participated on a volunteer basis in this study. The data were collected in three phases i.e. at the beginning, middle, and end of three months. The method and process of data collection consisted of three stages: 1) Before the intervention stage; 2) During the intervention stage and 3) After the intervention stage.

Measure

Slovakova et al. (2020) have used 3-parameters to measure anthropometrical indicators (body height and weight) of gymnasts, in this study the following anthropometric measuring instruments were used to measure 3-variables which are interpreted as follows; i) Weight scale for body weight, ii) Stadiometer for height, iii) BMI for body fat.

Statistical Analysis Tools

In order to calculate statistical data and get frequencies, percentages, mean and SD scores, etc. of this study, SPSS v.25 and MS Excel v.10 were used which are commonly used in this type of study.

Data Analysis and Result

Data Type

In this study, the primary data was collected through pre-test/post-test technique under the following 3-parts; i) Demographic Info, ii) Anthropometric height, weight, and BMI, and iii) Body Movements through Floor Exercises under FIG HP4, HP5.

Quantitative Data Analysis

The following tables show the results regarding 2-anthropometric indicators (physical growth) of professional and non-professional gymnasts along with the comparison between both types of gymnasts in pre-test and post-test data through mean score, standard deviation, and significant difference. Similarly, the below tables also indicate the impacts of proper application of rigorous training on body movements on 20-professional and 20-non-professional gymnasts in floor exercises through HP4 (Age=14-15) and HP5 (age=16-17) in high performance stream.

Demographic Characteristics

The following tables show the current status of demographic characteristics i.e. gender, age, club location, club name, group type, the financial condition of the family, competition participation, duration of gymnastics, and diet quality of this study's participants;

Table 4

Age-wise Participants

		Age				Total
		14	15	16	17	
Professional	Count	10	10	10	10	40
	%	50%	50%	50%	50%	50.0%
Non-Professional	Count	10	10	10	10	40
	%	50%	50%	50%	50%	50.0%
Total	Count	20	20	20	20	80
	%	25.0%	25.0%	25.0%	25.0%	100.0%

In Table 4, frequencies and percentages show that professional and non-professional gymnasts have equally (20, 25.0%) participated from all gymnastics clubs in this study.

Anthropometric Indicators and F.I.G authorised Body Movements (floor elements HP4 & HP5)

Table 5

Shapiro-Wilk Test Results for Normality of Data in Anthropometric Indicators

Sr.#		Statistic	Df	P
1	Weight	0.94	80	0.00*

Sr.#		Statistic	Df	P
2	Height	0.85	80	0.00*
3	BM-HP4	0.94	40	0.04*
4	BM-HP5	0.89	40	0.00*

The above table shows the Shapiro-Wilk statistics of 2-anthropometric indicators and 2-body movements floor elements regarding their normal distribution. The item having a significance (P-value) lower than .05 indicates that it does not bear normal distribution. There are four items that have lower significant values ($p<0.05$) which means they do not bear the normality of data distribution. The statistics against each item show the test statistics for four items while the "df" values show the level of freedom related to each test.

Table 6

Collected and derived data of examined Professional and Non-professional gymnasts. Data are expressed as mean ±SD and p values express differences between Professional and Non-professional gymnasts (14-17 before and after 12 weeks of rigorous training (RT).

Variables	Professional Gymnasts (n=40)			Non-professional Gymnasts (n=40)		
	Mean	SD	P	Mean	SD	P
Height before intervention	159.31	9.85		139.49	38.59	
Height after intervention	159.94	9.86		161.71	10.45	
Δ Before - After intervention Height	0.63	0.01	<0.001	22.22	-28.49	<0.001
Weight before intervention	48.89	10.53		47.18	9.16	
Weight after intervention	49.9	10.73		49.56	8.54	
Δ Before - After intervention Weight	1.01	0.2	<0.001	2.38	-0.62	<0.001
BMI before intervention	18.89	2.48		18.49	2.64	
BMI after intervention	19.24	2.71		18.89	2.4	
Δ Before - After intervention BMI	0.35	0.23	<0.001	0.4	-0.24	<0.001
RST-HP4 before intervention	0.28	0.31		1.19	0.22	
RST-HP4 after intervention	3.06	0.29		2.39	0.28	
Δ Before - After intervention RST-HP4	2.78	-0.02	<0.001	1.2	0.06	0.11
RST-HP5 before intervention	0.35	0.39		0.3	0.2	
RST-HP5 after intervention	3.13	0.34		0.34	0.27	
Δ Before - After intervention RST-HP5	2.78	-0.05	<0.001	0.04	0.07	0.21

The above table shows the statistics of the height of professionals in the pre-test and post-test which indicates mean and SD scores were found to be 159.31 ±9.85 in the pre-test and 159.94±9.86 in the post-test along with Mean % Dif. (0.63) in both tests and *p*-value ($0.001<0.05$) indicate that the difference is statistically significant in both pre & post-tests. And above table shows the statistics of the height of non-professionals in the pre-test and post-test which indicates mean and SD scores were 139.49±38.59 in the pre-test and 161.71±10.45 in the post-test along with Mean % Dif. (22.22) in both tests and *the P*-value ($0.001<0.05$) indicates that the difference is statistically significant in both pre & post-tests. The mean difference between both groups shows that the increase in height of professional gymnasts after RT intervention is less than that of non-professional gymnasts. The above table shows the statistics of the weight of professionals in the pre-test and post-test which indicates mean and SD scores were found 48.89±10.53 in the pre-test and 49.90±10.73 in the post-test along with Mean % Dif. (1.01) in both tests and *P*-value ($0.001<0.05$) indicate that the difference is statistically significant in both pre & post-tests. And above table shows the statistics of the weight of non-professionals in the pre-test and post-test which indicates mean and SD scores were found 47.18±9.16 in the pre-test and 49.56±8.54 in the post-test along with Mean % Dif. (2.38) in both tests and *the P*-value ($0.001<0.05$) indicates that the difference is statistically significant in both pre & post-tests. The mean difference between the two groups shows that professional gymnasts lift less weight than non-professional gymnasts after RT intervention. The above table shows the statistics of BMI of professionals in the

pre-test and post-test which indicates mean and SD scores were found 18.89±2.48 in the pre-test and 19.24±2.71 in the post-test along with Mean % Dif. (0.35) in both tests and *P*-value (0.001<.05) indicate that the difference is statistically significant in both pre & post-tests. And above table shows the statistics of BMI of non-professionals in the pre-test and post-test which indicates mean and SD scores were found 47.18±9.16 in the pre-test and 49.56±8.54 in the post-test along with Mean % Dif. (0.40) in both tests and *P*-value (0.001<0.05) indicate that the difference is statistically significant in both pre & post-tests. The mean difference between the two groups shows that professional gymnasts lift less BMI than non-professional gymnasts after RT intervention.

Table 7

Test Statistics of Wilcoxon Rank Test of Physical Growth (PG) of the Participants of both Groups (n=80) in Pre-test & Post-test

Participant ID		PG in Pre & Post Test
Professional Group	Z	-3.28[b]
	P. (2-tailed)	<.001
Non-Professional Group	Z	-3.27[b]
	P. (2-tailed)	<.001

a=Wilcoxon Signed Ranks Test. b=Based on positive ranks.

In order to know the significant differences in PG in participants of both groups in the pre & post-test, the Wilcoxon Rank test was run to obtain Z-scores. Table 7 shows a Z-score of -3.28 for the professional group and a Z-score of -3.27 for the non-professional group based on positive ranks under their physical growth. The Sig (2-tailed) value for both groups is <0.001 which indicates that the p-value of both groups regarding PG is less than zero. Due to positive ranks, the Z-score indicates that a significant decrease was found in the PG of both groups after the intervention of RT.

Discussion

In the light of previous studies, one hypothesis (1 null hypothesis and 1 alternative hypothesis) was formulated in this study regarding the effects of RT on the PG between ages 14-17 among male professional and non-professional gymnasts in AG. The results of data analysis against both hypotheses of this study are discussed below;

In order to measure and compare the differences in physical growth in 80 male professional and non-professional gymnasts, pre-tests and post-tests were conducted before and after the intervention of 12-week RT in this study. Mean % differences, significant level, and box plots were obtained through mean scores, std. deviation and p-values against physical growth wherein body weight, body height, and BMI show the overall physical growth level of participants. Regarding body height, the mean % difference in body height before and after RT in professional and non-professional artistic gymnasts were found 0.63 and 22.22 centimeters respectively which indicates that the increase in height of professional gymnasts after RT intervention is less than that of non-professional gymnasts. Regarding body weight, the mean % difference before and after RT in professional and non-professional artistic gymnasts was found 1.01 and 2.38 kilograms respectively which indicates that the weight of professional gymnasts decreased as compared to non-professional gymnasts after the intervention of RT. Regarding BMI, the mean % difference of two anthropometric indicators (weight, height) before and after RT in professional and non-professional artistic gymnasts was jointly found 0.35 and 0.40 respectively which indicates that professional gymnasts have increased BMI more than non-professional gymnasts after the intervention of RT.

The above results show that RT has more negative effects on the physical growth of male professionals as compared to non-professional gymnasts in Artistic Gymnastics. Similarly, output values of a 2-tailed significance level (p<0.01) show that height (0.50) and weight (0.42) have no significant relationship (p>0.01) with RT. Further, correlations of height and weight with RT are also shown in negative values. The findings of this study support our first null hypothesis that there is no significant effect of rigorous training on the physical growth of male professional and non-professional gymnasts in artistic gymnastics; therefore, the alternative hypothesis of this study is rejected.

Conclusion

The core objective of this study was to determine the influence of rigorous training on physical growth between ages 14-17 among professional and non-

professional gymnasts. For this purpose, a research design based on a randomized control trial (RCT) was adopted in which 80 participants were assimilated from 4-artistic gymnastic clubs belonging to different cities in Punjab-Pakistan. Primary data were collected through the intervention of 12 weeks of rigorous training from professional and non-professional male artistic gymnasts regarding their physical growth (body weight, body height) and BMI (for body fat and RT under FIG Codes of HP4 & HP5. In this phase, the overall results of the efficacy of RT have been considered, followed by a discussion of how this study can contribute to both our theoretical and practical understanding of PG and RT of artistic gymnasts. Finally, recommendations for the limitations arising from this work and possible directions for future research are given at the end.

Recommendations

1. The findings of this study indicate that RT has more negative and no significant effects on the physical growth of professional gymnasts as compared to non-professional gymnasts. Therefore, it can be assumed that the trainers and practitioners may avoid adopting RT during gymnastics, particularly for adolescents without proper implementation of international codes of practice i.e. FIG standards.
2. This study found that the professional group of artistic gymnasts performed better body movements as compared to the non-professional group in terms of agility, flexibility, muscle strength, flexibility, speed, endurance, and muscle power. Therefore, it is understood that the planned and long-term strategic application of the gymnastic training program will significantly improve children's physical growth and body movement.

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