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ORIGINAL

ACTIVE AND PASSIVE FLEXIBILITY EVALUATION IN SPANISH TRAMPOLINISTS

EVALUACIÓN DE LA FLEXIBILIDAD ACTIVA Y PASIVA EN TRAMPOLINISTAS ESPAÑOLES

Gómez-Landero Rodríguez, L.A.[1]; López Bedoya, J.[2] y Vernetta Santana, M.[2]

[1] Profesor Asociado Doctor. Departamento Deporte e Informática. Universidad Pablo Olavide. Sevilla. España. lagomrod@upo.es
[2] Profesores Titulares de Universidad. Departamento Educación Física y Deporte. Universidad de Granada. Granada. España. jlopezb@ugr.es y vernetta@ugr.es

Spanish-English translator: Bridgit McQue, e-mail: bmcq123@hotmail.com, University of Granada

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ABSTRACT

Introduction: Cross-sectional, comparative and correlational study of flexibility in Spanish trampolinists. Method: Sample of 60 national elite trampolinists, divided into 4 groups based on competitive categories: U-15 male (n = 23, 11.95 ± 1.79 years) and female (n = 9, 11.44 ± 1.23 years); Absolute male (n = 18, 20.72 ± 4.66 years) and female (n = 10, 16.1 ± 2.02 years. ROM was assessed by measuring angles and then analyzing them by digital photography for active and passive flexion and extension of trunk, shoulder, hip and abduction. Comparisons were made with each group and correlations between ROM and the points scored in exercises. Results: Both groups show higher female than male ROMs while ROMs of trunk and shoulders have higher correlations with the scores. Conclusions: The results suggest a lesser influence of flexibility in trampoline in relation to other gymnastic sports and requirements proper to the specialty.

KEY WORDS: Trampoline, gymnastics, range of motion, flexibility, male category, female category.

RESUMEN

Introducción: Estudio transversal, comparativo y correlacional sobre flexibilidad en trampolinistas españoles. Método: Muestra de 60 trampolinistas de élite nacional, agrupados por categoría competitiva en 4 grupos: Sub-15 masculino (n=23; 11,95±1,79 años) y femenino (n=9; 11,44±1,23 años); Absoluto masculino (n=18; 20,72±4,66 años) y femenino (n=10; 16,1±2,02 años). Mediciones de ángulos para evaluar el ROM mediante el análisis de fotografía digital, en las posiciones activas y pasivas de flexión y extensión de tronco y hombros, flexión y abducción de caderas. Se han realizado comparaciones de grupos entre sí y correlaciones entre el ROM y las notas de los ejercicios. Resultados: Los grupos femeninos muestran mayores ROMs que los masculinos; los ROMs de flexión de tronco y hombros presentan mayores correlaciones significativas con las puntuaciones. Conclusiones: los resultados sugieren una menor influencia de la flexibilidad en el Trampolín en relación a otros deportes gimnásticos, con unas exigencias características de la especialidad.

PALABRAS CLAVE: Trampolín, Gimnasia, Rango de movimiento, Flexibilidad, Categoría masculina, Categoría femenina.

INTRODUCTION

The requirements for physical fitness necessary to practice a sport will be more or less demanding depending on motor characteristics and differentiating levels from practicing or non-competitive basis to high performance sports. In speaking of the trampoline (the official term), Ferreira, Araujo, Botelho and Rocha (2004) indicate that this gymnastic modality consisting of continuous movements requires high levels of flexibility among other physical qualities.

Flexibility as a component of physical condition has been studied to obtain an impression of a person's physical capacity; in scientific research within sport sciences its relationship to performance and injury prevention has been particularly studied (Reid, Burnham, Saboe and Kushner, 1987; Lysens et al 1989, Gore, 2000; Gremion, 2005, McNeal and Sands, 2006; Sands, McNeal, Stone, Russell.and Jemni, 2006, Kinser, Ramsey, O'Bryant, Ayres, Sands and Stone, 2008; Sands, McNeal, Stone, Kimmel, Haff, and Jemni 2008 ;). Equally, flexibility is also taken into account as an influential variable in the motor execution of various basic motor skills (Delas, Miletic and Miletic, 2008).

Flexibility is defined as the physical quality that allows us to mobilize segments to achieve wide ranges of articular motion (ROM: Range of Motion or Range of Movement). The ROM of a joint is the measurement of the angle that determines the relative position of two body segments joined together by a common bond, the joint. This angular variable is used consistently in research as an indicator of flexibility (Robles, Vernetta and Lopez Bedoya, 2009).

Within the evaluation and study of static flexibility it is important to differentiate between active or passive flexibility; the first refers to the maximum ROM produced by voluntary isometric muscle contraction, while the second refers to the maximum ROM achieved by applying an external force up to the threshold of pain without actually cause joint damage (Siff and Verkhoshansky, 2000).

In a study on the relationship between active and passive flexibility in various Olympic sports, Iashvili (1983) noted that greater skill was associated with higher ROMs obtained actively and passively while active flexibility correlates more with sports performance ($r = 0.81$) than passive flexibility ($r = 0.69$); he also noted that the pattern and degree of joint mobility are specific to each sport; gymnasts obtained very high values of active and passive flexibility in the coxofemoral joint among all athletes in the study. Moreover, a marked difference between active and passive flexibility (a measurement known as inflexibility) established a higher correlation with the incidence of soft tissue injuries.

In some sports, such as gymnastic sports, athletes need a high ROM to perform certain movements or acquire specific static positions (Harvey and Mansfield, 2000), making flexibility a decisive physical quality in performance. A gymnast who lacks flexibility in a joint linked to the execution of a particular movement will increase the risk of injury by having to use other compensatory mechanisms. This also causes uncoordinated movements and low ROM, with a marked decrease in mechanical efficiency, poorer performance and increased chance of injury (Shellock and Prentice, 1985). This poor performance compared to the established model also receives high penalties in the scores in the respective codes of different gymnastic sports.

According to McNitt-Gray (1994), flexibility is perhaps the capacity that best distinguishes the characteristics of gymnasts as they are able to demonstrate a greater ROM in positions than athletes from other sports (Kirby, Simms, Symington, Garner (1981). Gymnasts must be proficient in both active and passive flexibility (Kirkendall, 1985; Alter, 1988). Passive flexibility almost always precedes active flexibility training, which is more difficult to achieve and more appreciated in the gymnasium (Sands and McNeal, 2000).

Studies on flexibility and gymnastic sports have focused primarily on Rhythmic Gymnastics, and Men and Women's Artistic Gymnastics, and seldom on the trampoline.

Flexibility tests are a constant in the batteries of tests for the detection and selection of sporting talents (Lopez Bedoya, Vernetta and Morenilla 1996; Morenilla, Lopez Bedoya and Vernetta, 1996; Lopez Bedoya and Vernetta, 1997). In the program for selecting and monitoring talented gymnasts, Bajin (1987) presents a set of tests with various components located on three levels: physical, motor and mental skills. The physical component stands out as most important, divided into two blocks of flexibility and strength, also differentiating passive and active flexibility within the block of flexibility at all levels. Singh, Rana and Walia (1987) found that part of the male gymnasts' performance was explained by the opening of the legs, the splits. Jankarik and Salmela (1987) measured a large set of different types of variables of elite Canadian gymnasts including active and passive flexibility tests; they noted that significant changes in active hip flexibility and morphological measurements of the gymnasts had a constant correlation with age in the period studied.

Greater ROMs are found in women's gymnastics such as Women's Artistic Gymnastics (Sands and McNeal, 2000) or Rhythmic Gymnastics (Menezes and Filho, 2006; Douda, Toubekis, Avloniti and Tokmakidis, 2008) through studies aimed at identifying potential performance-related variables or comparing groups with different levels of performance. Overall, female populations show greater flexibility than male; Araujo (2008), who provides normative values of non-athletic male and female populations, from ages 5 to 91, also noted higher ROM in women.

It was observed that excessive demand made of the spinal column in the active or passive movement, with extreme hyperextensions and rotations, can be connected to the occurrence of injuries or diseases, found more frequently in female Artistic Gymnastics (Hubley-Kozey and Stanish, 1990), and Rhythmic Gymnastics (Volpi, Cunha, Grillo, Moya and Ayumi, 2008).

Smoleuskiy and Gaverdouskiy (1996) considered the "model" of joint flexibility for Artistic Gymnastics is determined by the execution of three types of splits (right or left leg in front and front splits), where the flexibility of the coxofemoral joint is decisive, bending forward from the trunk until the chest is on the thighs and the ability to keep the leg in front for at least 2 seconds (hip flexion) and laterally (abduction) above shoulder-height. Sands (2000) also indicates that the glenohumeral joint shows high levels of flexibility in Artistic Gymnastics.

Leon (2006) analyzed active and passive flexibility of the hip on different planes and positions in elite adult gymnasts in Men's Artistic Gymnastics, correlating the ROM measurements obtained with the sporting performance of gymnasts. He noted that passive flexibility of the hips in the frontal plane was associated with higher scores in pommel horse and high bar.

In trampoline there are no static flexible positions as in other gymnastic sports, since the movements are continuous. In certain acrobatic positions, the Trampoline Code of Points (FIG, 2009) does not require the high level of ROM for hips or shoulders demanded by the respective codes of Artistic Gymnastics; however, it does require a high ROM to allow full flexion of the dorso-lumber joint together with hip flexion while maintaining the extension of the knees, known as the piked position or legs bent at the knees and trunk-straddle (open pike). It also requires a straight line throughout the entire length of the lower body, finishing with the foot "pointed", with the consequent demands on ankle plantar flexion and MTP. From the technical standpoint, a correct vertical positioning of the upper part of the body when jumping from the bed of the trampoline is also important. This hyperflexion of the shoulder is characteristic, especially during jumps with a backward rotation (Kelly, 2005).

In the Jump Start Testing battery of tests for selecting sporting talents in trampoline, proposed by the United States of America Federation of Gymnastics (USA Gymnastics, 2009), flexibility tests are included among other specific tests for strength, general fitness, speed and technical skills. Measures are taken of the trunk-leg flexion (sit and reach), splits and shoulder flexions, these points being a percentage of the total valuation of the trampolinist in competition. However, the data justifying the weighting and thus its degree of validity are not known.

The only work we have found that included an assessment of flexibility in trampoline corresponding to pilot studies prior to this present study are Gómez-Landero, Lopez Bedoya, Vernetta, and Fernandez, 2006a, and Gomez-Landero, Lopez Bedoya, Vernetta, Jiménez and Gutiérrez, 2006b on various morphological and functional characteristics in the Spanish men's trampoline team (n = 7). ROMs were observed to be generally lower than those shown in Artistic Gymnastics.

In the review we conducted we found no studies that analyze specifically trampolinists' flexibility, nor any that demonstrated the relationship of this ability to sports performance. This study therefore has two objectives: to evaluate the active and passive ROM in Spanish trampolinists of different competitive categories (male and female) and different age groups (Under 15 and Absolute), and secondly, to analyze the relationship between the average ROM and the difficulty trampolinists found in doing exercises.

MATERIALS AND METHODS

Participants

A total of 60 participants were divided into 4 groups according to the national competitive categories: GM1 with 23 Under-15 males (11.95 ± 1.79 years), GM2 Absolute category with 18 males (20.72 ± 4.66 years), GF1 with 9 Under-15 females (11.44 ± 1.23 years) and GF2 Absolute with 10 women (16.1 ± 2.02 years). The trampolinists were selected from the national elite, under the guidance of the National Technical Committee. All subjects agreed to participate, giving written informed consent according to the ethical standards for human research of the Declaration of Helsinki.

Instruments

F200 Minolta Dimage digital cameras were used with up to 4 megapixel resolution and tripod. To obtain data of the angles, we used the program for the analysis of sports technique *ADT 2*.0 (*Analysis of Sports Techniques, program Arellano and Garcia, 2000,* University of Granada, Spain, contact: arellano@ugr.es). For the development of all statistical tests and the preparation of charts and graphs, we used SPSS v.15.1 and Office Excel 2007.

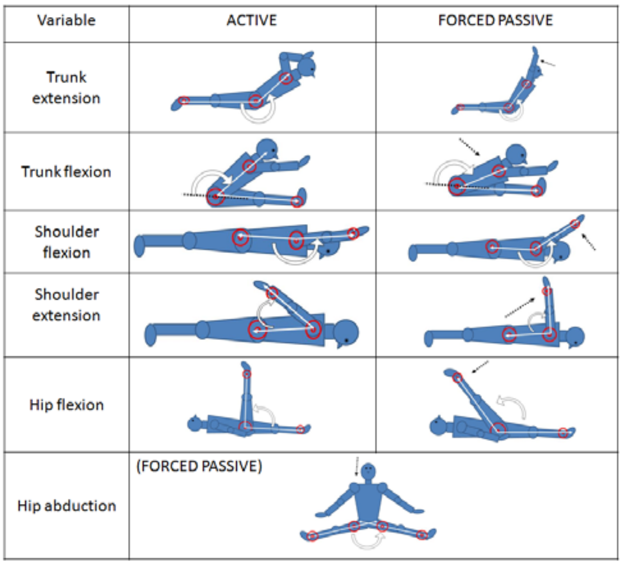
Procedure

We performed a cross-sectional, descriptive and correlational study with intergroup comparisons aimed at analyzing the variables and correlations between variables of flexibility and sports performance. The participants were measured just the week after taking part in the National Championship, so that all were in good form.

ROMs of the main groups involved in both active and passive joint movements characteristic of trampoline were measured in degrees. The variables studied were active ROM (A) and passive ROM (P) as follows: trunk extension (R_ATE and R_PTE) trunk flexion (R_ ATF and R_PTF) shoulder flexion (R_ASF and R_PSF) shoulder extension (R_ASE and R_PSE) hip flexion (R_AHF and R_PHF), calculated from the mean value obtained in the right and left hip and passive hip abduction (R_PHA). Athletic performance variables were taken from the scores obtained in the National Championship prior to the measurements: Difficulty, Execution and Final Score (weighted sum of the above).

Figure 1 shows several schematic drawings of each of the angles measured as variables related to flexibility in Trampoline.

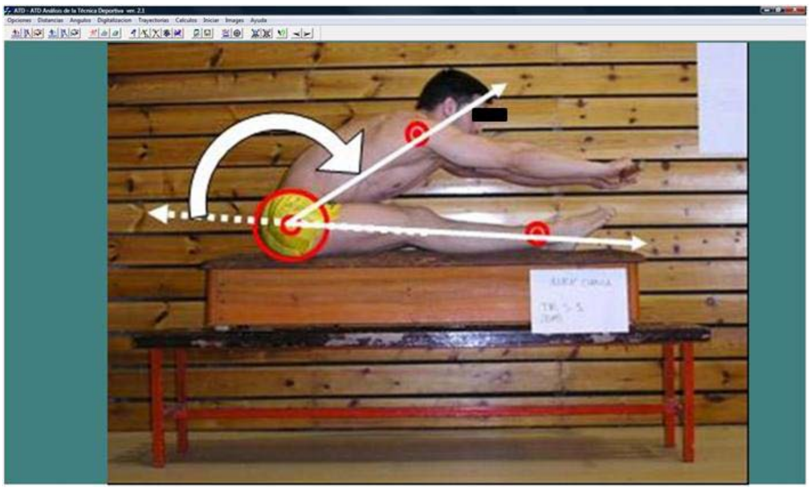
Figure 1. Angles measured to assess the range of motion.



The reference points of the joints are marked with a white sticker, always taking the right side of the participants except for hip abduction (frontal plane) and hip flexion (right and left). After a proper warm-up, they had to maintain the position for 2 s with maximum active and forced passive ROM with the help of an evaluator, following the general procedures established by Dunlevy, Cooney and Gormely (2005).

Each angle was measured by the ATD program by two reviewers, obtaining the average value by controlling at all times an inter-observer variation coefficient of less than 5%. As an example, the measurement of R_TFA using ATD is shown schematically in Figure 2.

Figure 2. Measurement of trunk flexion ROM by ADT.



The descriptive statistical analysis performed included the mean (M), standard deviation (SD) and the measure as a percentage as the coefficient of variation (CV). In the analysis of the distribution of the data the Shapiro-Wilk test was used to check if the data passed the normality test. If a normal distribution was confirmed, a t test was used to compare independent samples with a 95% confidence interval (CI). To check the homogeneity of variances Levene's test was used; if homogeneous variances were found we proceeded with the Student t test; in case of heterogeneity Welch's test was used. If a normal distribution test was not confirmed we used the Mann-Whitney U test. For the correlation coefficient we used the Pearson correlation coefficient for normal distribution of variables and that of Spearman for those that did not show normality.

RESULTS

In the comparison of ROM the active values alternate with the passive in both tables and figures. First the comparisons between groups GM1 and GM2 (Table 1) are presented, noting statistically significant differences favoring the Under-15 group in the ROM of active trunk flexion (p = 0.018) and active and passive shoulder extension (p = 0.000 for both). The mean values are higher in the GM1 group in all cases except in active shoulder flexion (177.29º in GM1and 186.60 º in GM2) and passive shoulder flexion (205.83º in GM1 and 206.05 º in GM2).

Table 1. Comparison of variables of active and passive range of motion between Groups GM1 and GM2.

Variables compared	GM1		GM2		Significance (bilateral)	CI 95%	
	M	SD	M	SD		Upper	Lower
Range Act. Trunk Flex.	134,56	7,71	125,87	12,48	0,018	1,63	15,76
Range Pas. Trunk Flex.	140,30	7,16	134,26	11,45	0,067	-0,45	12,53
Range Act. Trunk Ext.	27,03	8,26	25,53	11,72	0,686	-5,98	8,97
Range Pas. Trunk Ext.	48,82	13,26	47,17	11,20	0,687	-6,57	9,87
Range Act. Shoulder Flex.	177,29	13,23	186,60	17,58	0,967		
Range Pas. Shoulder Flex.	205,83	12,43	206,05	14,50	0,961	-8,99	8,57
Range Act. Shoulder Ext.	85,75	13,18	64,09	11,67	0,000	13,36	29,97
Range Pas. Shoulder Ext.	104,77	13,28	87,23	13,91	0,000	8,61	26,47
Range Act. Hip Flex.	93,25	8,99	92,32	10,53	0,797	-6,38	8,24
Range Pas. Hip Flex.	118,11	14,24	113,15	15,29	0,376	-6,29	16,20
Range Pas. Hip Abd.	134,39	18,92	121,47	19,72	0,096	-2,45	28,29

Mann-Whitney U / Student t/ unequal variances t (Welch) | p<0,05

Between the female groups (Table 2) the differences are very slight, appearing at p <0.05 only in the ROM of passive shoulder flexion (p = 0.044).

Table 2. Comparison of variables of active and passive range of motion between Groups GF1 and GF2.

Variables compared	GF1		GF2		Significance (bilateral)	CI 95%	
	M	SD	M	SD		Upper	Lower
Range Act. Trunk Flex.	144,11	7,31	143,92	11,78	0,968	-9,61	9,98
Range Pas. Trunk Flex.	149,99	9,45	151,03	12,24	0,643		
Range Act. Trunk Ext.	38,00	10,67	35,21	14,48	0,655	-10,26	15,83
Range Pas. Trunk Ext.	62,47	13,02	54,37	15,57	0,208		
Range Act. Shoulder Flex.	184,91	13,97	184,56	21,02	0,967	-17,49	18,19
Range Pas. Shoulder Flex.	215,79	7,03	203,98	14,33	0,044	0,36	23,26
Range Act. Shoulder Ext.	92,23	9,47	88,24	12,19	0,449	-6,92	14,90
Range Pas. Shoulder Ext.	111,30	9,76	105,05	14,18	0,292	-5,91	18,41
Range Act. Hip Flex.	107,59	11,12	105,98	13,95	0,790	-11,00	14,22
Range Pas. Hip Flex.	134,35	13,00	138,61	25,00	0,658	-24,72	16,20
Range Pas. Hip Abd.	147,81	22,20	150,34	24,50	0,827	-26,82	21,76

Mann-Whitney U / Student t/ unequal variances t (Welch) | p<0,05

The mean values are higher in GF1 for all variables except passive trunk flexion (149.99 º in GF1 and 151.03 º in GF2), hip flexion (134.35 º in GF1 and 138.61 º

in GF2) and passive hip abduction (147.81º GF1 and 150.34 º GF2).
When making comparisons between categories (Table 3 and 4) we found numerous significant differences.

Table 3. Comparison of variables on active and passive range of motion between Groups GM1 and GF1.

Variables compared	GM1		GF1		Significance (bilateral)	CI 95%	
	M	SD	M	SD		Upper	Lower
Range Act. Trunk Flex.	134,56	7,71	144,11	7,31	0,003	-15,65	-3,44
Range Pas. Trunk Flex.	140,30	7,16	149,99	9,45	0,029		
Range Act. Trunk Ext.	27,03	8,26	38,00	10,67	0,004	-18,17	-3,77
Range Pas. Trunk Ext.	48,82	13,26	62,47	13,02	0,018	-24,73	-2,57
Range Act. Shoulder Flex.	177,29	13,23	184,91	13,97	0,046		
Range Pas. Shoulder Flex.	205,83	12,43	215,79	7,03	0,009	-17,15	-2,77
Range Act. Shoulder Ext.	85,75	13,18	92,23	9,47	0,190	-16,36	3,40
Range Pas. Shoulder Ext.	104,77	13,28	111,30	9,76	0,191	-16,52	3,45
Range Act. Hip Flex.	93,25	8,99	107,59	11,12	0,001	-22,05	-6,63
Range Pas. Hip Flex.	118,11	14,24	134,35	13,00	0,006	-27,42	-5,06
Range Pas. Hip Abd.	134,39	18,92	147,81	22,20	0,109	-30,00	3,17

Mann-Whitney U / Student t / unequal variances t (Welch) | p<0,05

Comparisons between the Under-15 groups (Table 3) have higher average values for all variables for Group GF1, with p values <0.05 for all variables except in the ROM of active shoulder extension (85.75 º in GM1 and 92.23 ° in GF1, p = 0.190) and passive shoulder extension (104.77 º in GM1 and 111.30º in GF1, p=0.191), as well as in hip abduction (134.39º in GM1 and 147,81º in GF1, p=0.109).

In the absolute groups there are higher average values for all variables for the female group (GF2) except for ROM in active shoulder flexion (186.60º in GM2 and 184.56º in GF2, p=0.797) and passive shoulder flexion (206.05º in GM2 and 203.98º in GF2, p=0.744). The statistically significant differences for p<0.05 are given in all ROMs analyzed except trunk extension and shoulder flexion.

Table 4 Comparison of variables on active and passive range of motion between Groups GM2 and GF2.

Variables compared	GM2		GF2		Significance (bilateral)	CI 95%	
	M	SD	M	SD		Upper	Lower
Range Act. Trunk Flex.	125,87	12,48	143,92	11,78	0,002	-28,48	-7,63
Range Pas. Trunk Flex.	134,26	11,45	151,03	12,24	0,005		
Range Act. Trunk Ext.	25,53	11,72	35,21	14,48	0,149	-23,23	3,87
Range Pas. Trunk Ext.	47,17	11,20	54,37	15,57	0,270		
Range Act. Shoulder Flex.	186,60	17,58	184,56	21,02	0,797	-14,21	18,29
Range Pas. Shoulder Flex.	206,05	14,50	203,98	14,33	0,744	-10,91	15,03
Range Act. Shoulder Ext.	64,09	11,67	88,24	12,19	0,000	-34,37	-13,93
Range Pas. Shoulder Ext.	87,23	13,91	105,05	14,18	0,006	-29,90	-5,76
Range Act. Hip Flex.	92,32	10,53	105,98	13,95	0,027	-25,54	-1,77
Range Pas. Hip Flex.	113,15	15,29	138,61	25,00	0,020	-46,28	-4,64
Range Pas. Hip Abd.	121,47	19,72	150,34	24,50	0,014	-51,10	-6,64

Mann-Whitney U / Student t / unequal variances t (Welch) | p<0,05

Table 5 shows the CVs of each of the variables of ROM in all the groups analyzed, as well as the average CV of each group and each variable. The Under-15 groups in general show less dispersion (average CV in GM1= 13.26 and GF1=11.38); the CVs increase in groups GM2 and GF2 until reaching average values close to 16%.

Table 5. Summary of the coefficients of variance of the variables of range of motion of groups GM1, GM2, GF1, GF2.

GROUP	R_ATF	R_PTF	R_ATE	R_PTE	R_ASF	R_PSF	R_ASE	R_PSE	R_AHF	R_PHF	R_PHA	M
GM1	5,73	5,10	30,54	27,15	7,46	6,04	15,37	12,67	9,64	12,06	14,08	13,26
GM2	9,92	8,53	45,90	23,74	9,42	7,04	18,21	15,94	11,40	13,52	16,24	16,35
GF1	5,07	6,30	28,09	20,84	7,55	3,26	10,27	8,77	10,33	9,68	15,02	11,38
GF2	8,18	8,10	41,13	28,64	11,39	7,02	13,82	13,50	13,17	18,04	16,30	16,30
M	7,23	7,01	36,42	25,09	8,96	5,84	14,42	12,72	11,14	13,32	15,41	

The most homogeneous variables among all the groups are ROMs of active and passive trunk flexion of the trunk (R_ATF, R_PTF) and the ROMs of active and passive shoulder flexion of the shoulder (R_ASF, R_PSF).

Finally we present the significant correlations between the variables of ROM and sports performance in all groups studied. Almost all significant associations found are moderate (0.300 ≤ r ≥ 0.700) or strong (r> 0.700), as classified by Martínez-González, Sanchez-Villegas and Faulin (2008).

Table 6. Significant correlations (p <0.05) between variables of ROM and scores in the groups studied.

GROUPS		GM1				GM2				GF1				GF2			
ASSOCIATED VARIABLES		Age	Diffic.	Exec.	Final	Age	Diffic.	Exec.	Final	Age	Diffic.	Exec.	Final	Age	Diffic.	Exec.	Final
ROM Act. Trunk Flex.	Coef. Correl.	0,494	0,507		0,449												0,745
	Sig. (bilateral)	0,017	0,014		0,032												0,021
	N	23	23		23												9
ROM Pas. Trunk Flex.	Coef. Correl.	0,438	0,508		0,508								0,786				
	Sig. (bilateral)	0,037	0,013		0,013								0,036				
	N	23	23		23								7				
ROM Act. Trunk Ext.	Coef. Correl.												-0,767				
	Sig. (bilateral)												0,016				
	N												9				
ROM Pas. Trunk Ext.	Coef. Correl.												-0,810				
	Sig. (bilateral)												0,015				
	N												8				
ROM Act. Shoulder Flex.	Coef. Correl.	0,459															
	Sig. (bilateral)	0,028															
	N	23															
ROM Pas. Shoulder Flex.	Coef. Correl.	0,424															
	Sig. (bilateral)	0,044															
	N	23															
ROM Ext. Hombro Act.	Coef. Correl.	-0,669															
	Sig. (bilateral)	0,000															
	N	23															
ROM Act. Hip Flex	Coef. Correl.			0,585	0,521												
	Sig. (bilateral)			0,003	0,011												
	N			23	23												
ROM Pas. Hip Flex	Coef. Correl.					0,731											
	Sig. (bilateral)					0,016											
	N					10											
ROM Pas. Hip Abd.	Coef. Correl.							-0,726			-0,805				0,747		
	Sig. (bilateral)							0,027			0,016				0,021		
	N							9			8				9		

Pearson Correlation / Spearman Correlation

In general there are very few significant associations between ROM and athletic performance shown in competition. The greatest number of significant correlations are in GM1, with all being either moderate or positive (except for active shoulder extension, r = -0.669). The ROM most related to sports performance corresponds to the muscular action of trunk flexion, showing positive correlations in groups GM1, GF1 and GF2. Active hip flexion, like active trunk flexion, is also related directly and significantly in GM1.

Several contradictory associations are found, alternating positive or negative values according to the group, as is the case with Hip Abduction (r = -0.726 and -0.805 in GM2 and GF1, r = 0.747 in GF2). The most positive associations of scores on the performance variables are those related to Final Scores followed by Difficulty. Age was positively correlated with the ROM especially in GM1.

DISCUSSION

After analyzing the dispersion of the variables minor CVs were observed in the Under-15 groups, increasing substantially in the Absolute groups; these results suggest a widening gap between older trampolinists with more experience in specific flexibility training.

The greater homogeneity of the variables found in trunk flexion (R_ATF and R_PTF) and shoulder flexion (R_ASF and R_PSF), with the lowest CVs, may be related to the motor demands characteristic of trampoline; piked positions (flexion of trunk-legs) included in the Code of Points (FIG, 2009) are among the most important positions together with the aligned placement of the arms with a slight shoulder hyperflexion, a technical requirement for the efficient execution of jumps from the bed of the trampoline, especially for subsequent backward rotations (Kelly, 2005).

In the comparative analysis between male and female categories, women's groups clearly have higher ROMs in general. Comparing GM1-GF1, there are statistically significant differences in all variables except for the ROMs of active trunk extension, passive trunk flexion and passive hip abduction (R_ETA, R_PTF and R_PHA). When comparing groups GM2-GF2 the same result is found except in active and passive trunk extension and shoulder flexion. Our results agree with the higher ROMs in female populations observed in the scientific literature (Gannon and Bird, 1999; Araujo, 2008).

These results are also associated with higher ROMs manifested in women's gymnastics specialties such as Artistic Gymnastics (Sands and McNeal, 2000) or Rhythmic Gymnastics (Menezes and Filho, 2006; Douda et al, 2008). The values obtained in the trampolinists in groups GF1 and GF2 are in any event much lower than those present in women's Artistic or Rhythmic Gymnastics, especially in the mobility of the hip, back and shoulder girdle.

Male trampolinists (GM1 and GM2) have generally lower values in ROMs compared with male gymnasts in specialties such as Artistic Gumnastics. With a protocol similar to that used in this study for measuring hip abduction and flexion of the trunk, Leon (2006) found much higher values of flexibility in the Men's Spanish National Artistic Gymnastics team. The higher mobility requirements in that specialty are also typically found in shoulder mobility (Sands, 2000) and hip flexion (Smoleuskiy and Gaverdouskiy, 1996).

When comparing age groups (GM1 - GM2, GF1 - GF2) there were no major differences, although those that we found are more pronounced in the male category. By correlating the flexibility data of the entire male and female sample according to age the only statistically significant correlations have appeared in men (Table 7), and were moderate or weak, whether positive or negative. This set of results does not indicate a clear influence of age on the flexibility of the trampolinists studied, in either the men' or women's categories. In this sense, our results are not consistent with studies of generic populations (non-athletes) on the evolution of flexibility that indicate a loss over the years that is more pronounced in women than in men and with an uneven evolution in each joint (Araujo, 2008).

Table 7. Statistically significant correlations (p <0.05) between variables of ROM and age in the masculine category.

ASSOCIATED VARIABLES		AGE
ROM Act. Shoulder Flex.	Coef. Correl. Pearson	0,413
	Sig. (bilateral)	0,009
	N	39
ROM Act. Shoulder Ext.	Coef. Correl. Pearson	-0,626
	Sig. (bilateral)	0,000
	N	39
ROM Pas. Shoulder Ext.	Coef. Correl. Pearson	-0,461
	Sig. (bilateral)	0,003
	N	39

When analyzing the correlations between variables related to active or passive flexibility and athletic performance few significant associations were observed in general, possibly indicating less influence of this physical quality in trampoline gymnastics compared with other sports in which there are greater links with athletic performance, such as Women's and Men's Artistic Gymnastics (Shellock and Prentice, 1985, Singh et al, 1987; Harvey and Mansfield, 2000; Sands and McNeal, 2000, Leon, 2006) or Rhythmic Gymnastics (Menezes and Filho, 2006; Douda, Toubekis, Avloniti and Tokmakidis, 2008).

Numerous significant and positive correlations in trunk flexion have been observed in the scores for Difficulty in three of the four groups (GM1, GF1 and GF2). These results again emphasize the importance of the mobility of that set of joints as a required feature of trampoline performance, as discussed above.

Finally, it is interesting to note the inclusion in the Jump Start Testing (USA-Gymnastics, 2009) of tests including assessment of the ROM of trunk flexion (5% of the total mark), shoulders (4%) and hips (splits with right and left leg, 6%). However, this set of tests for evaluating trampolinists' flexibility represent only 15% of the total score that assesses the ability of future trampolinists, the most important measures being upper body strength (26%), lower body strength (23%) and scores in exercises and technical skills (36%). The importance that this battery of tests gives to the ROMs of trunk and shoulder flexion is in line with the results of our work.

In conclusion, this paper highlights the unique profile of trampolinists in relation to ROM, with lower requirements than other gymnastic sports such as artistic or rhythmic gymnastics, with trunk and shoulder flexions being the most characteristic actions with the highest demands for mobility.

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