Biological, physical fitness and motor coordination profile and its associations with the performance of practitioners of rhythmic gymnastics at sports initiation: a systematic review

Perfil biológico, de aptidão física e de coordenação motora e suas associações com o desempenho de praticantes de ginástica rítmica em iniciação esportiva: uma revisão sistemática

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Abstract - Describing the biological, physical fitness and motor coordination profile and its possible associations of these variables with the performance on rhythmic gymnastics (RG) of practitioners of sports initiation. Systematic search of articles carried out from the 20th to the 23rd of July, 2022, on three databases: 1) PubMed; 2) *SportDiscus* and 3) Google Scholar. The search was conducted through an advanced research tool, from the constructing of descriptors and keywords related to the theme. The selection of descriptors and keywords was performed through consensus of published sources (original and of systematic review articles) and inserted in English language in each database. 10 articles were included in the descriptive summary of data. The greatest part of these studies is of female practitioners, having the data collection in its majority in the European region. The profile of beginner gymnasts was characterized by low values for BMI, BF%, high values for stature, high indexes of flexibility, explosive strength, motor coordination and balance. Flexibility, explosive strength, muscular endurance and high levels of motor coordination were the variables which most presented positive associations with the performance on RG. The values of body mass and skin folds presented a predictive negative power on the success of RG movements. The impact of different variables on the beginner gymnasts' performance evidences the necessity of working physical and motor components in a way that it supports the objects of development of each practitioner considering the biological, physical and motor aspects.

Keywords: Gymnastics; Initiation; Performance.

Resumo - *Descrever o perfil biológico, de aptidão física e de coordenação motora e compreender as possíveis associações entre essas variáveis com o desempenho na ginástica rítmica (GR) de praticantes de iniciação esportiva. Busca sistemática dos artigos realizada de 20 a 23 de julho de 2022 em três bases de dados: 1) PubMed; 2) SportDiscus e 3) Google Scholar. A busca foi realizada mediante ferramenta de pesquisa avançada, a partir da construção de descritores e palavras-chave relacionadas à temática. A seleção dos descritores e palavras-chave foi realizada por meio de consenso em fontes publicadas (artigos originais e de revisão sistemática) e inseridas na língua inglesa em todas base de dados. 10 artigos foram incluídos na síntese descritiva dos dados. A maior parte destes estudos eram com praticantes do sexo feminino, com coleta de dados realizados na sua maioria na região Europeia. O perfil das ginastas iniciantes foi caracterizado por baixos valores para IMC, %GC, altos valores para estatura, altos índices de flexibilidade, força explosiva, coordenação motora e equilíbrio. A flexibilidade, a força explosiva, a resistência muscular e altos níveis de coordenação motora foram as variáveis que mais apresentaram associações positivas com o desempenho na GR. Já os valores de massa corporal e dobras cutâneas apresentam um poder preditivo negativo no sucesso dos movimentos da GR. O impacto de diferentes variáveis no desempenho de ginastas iniciantes, evidencia a necessidade de trabalhar componentes físicos e motores de modo que atenda os objetos de desenvolvimento de cada praticante considerando os aspectos biológicos, físicos e motores.*

Palavras-chave: *Ginástica; Iniciação; Performance.*

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INTRODUCTION

The sports formation is a phenomenon that presents different stages and it happens throughout one's life, which can result in experiences that stimulate and keep the subjects active from childhood to adult life[1]. The sports initiation (SI) is the first phase of this formation in which basic aspects of one or more modalities are taught and learnt in a specific or planned way aiming the development as a whole, without necessarily driving them to competitions[2].

It is known that SI has been a broad discussion on distinctive sports including Rhythmic Gymnastics (RG)[3]. RG is a modality of interest for SI, for it presents movements and abilities very close to the corporal culture found in children's playing[3], besides contributing to the development of physical and motor abilities[4]. This sport is characterized for being aesthetic, in which the size and body structure contribute significantly to the practitioner's performance[5]. In this context, the term performance refers to a gymnast or group accomplish in a physical, technical shape together with psychological strength with the maximum efficiency possible[6]. The ideal development is the result of a complex interaction of several factors[7].

Studies on SI suggest that the main morphologic characteristics which describe the beginner gymnasts' profile are: low values for BMI and BF% and high values for stature[8,9]. The performance on RG, with or without the use of apparatus, is positively related with the flexibility level, explosive power and parameters of pubertal development of beginner practitioners[10-13]. High levels of general coordination, rhythm coordination, levels of balance and agility are also associated positively with the performance on this modality in the SI[12-14].

Although there is an extensive number of articles focused on the association of variables with performance on RG, it is verified a low number of researches which investigate the variables that describe and determine performance levels of children/adolescents in the scope of SI. Great part of the studies found in literature are directed to elite athletes[15-17]. Furthermore, it is highlighted the scarcity of reviews which better comprehend the concordance or not among the existing studies aiming the description of these gymnasts' profile and the possible association of individual variables with performance. It is from this knowledge that teachers and coaches can identify and suggest movements with components that really affect the RG practice[18].

Thus, the objectives of this systematic review are: (i) to describe the biological characteristics (anthropometric, body composition and maturation), physical fitness characteristics (explosive strength, flexibility, muscular endurance, aerobic endurance and agility) and motor coordination characteristics (balance, rhythm, strength, laterality and speed) of children/adolescents practitioners of RG in the SI; (ii) analyze which are the associations among the biological characteristics (anthropometric, body composition and maturation), physical fitness characteristics (explosive strength, flexibility, muscular endurance, aerobic endurance and agility) and motor coordination characteristics (balance, rhythm, strength, laterality and speed) with the performance of children/adolescents on RG, in the SI.

METHOD

The report of this review is in agreement with the Preferred Reporting Items for Systematic Reviews (PRISMA)[19].

Sources of information

The systematic search of the articles was carried out from the 20th to the 23rd of July, 2022 on three databases: 1) Medical Literature Analysis and Retrieval System Online (MEDLINE), through PubMed; 2) *SportDiscus*, through the platform EBSCOhost and 3) Google Scholar.

Search strategy, descriptors and keywords

The search for articles on the databases was conducted through an advanced research tool, from the constructing of descriptors and keywords related to the theme. The selection of descriptors and keywords was performed through consensus of published sources (original and of systematic review articles) and inserted in English language in every database.

Overall, five descriptors and keywords were defined. The first one was composed by the population of interest in this study: *"gymnasts"*. The second one was composed by the terms related to performance: "performance". The third one by terms related to the sport of interest: "rhythmic gymnastics". The fourth one composed by terms related to SI: "initiation". And the fifth one composed by the term related to the sample level: "novices".

The operator "AND" was used to relate the blocks of keywords/descriptors among themselves. In addition, quotation marks were used on compound words and to search for exact terms or expressions.

Eligibility criteria

The inclusion criteria were: a) studies with cross-sectional, longitudinal or intervention design which described the profile of RG practitioners in initiation groups related to individual characteristics (biological variables, physical fitness and motor coordination); b) studies with cross-sectional, longitudinal or intervention design which made association of any variable related to individual characteristics (biological variables, physical fitness and motor coordination) with any performance variable on RG in initiation groups; c) population composed by beginner gymnasts, children or adolescents (age range from 6 to 19 years); d) studies published in English, Portuguese or Spanish language.

Exclusion criteria

The exclusion criteria were: a) theses, dissertations, monographs, abstracts, book chapters, conferences, review or point of view articles, validation and/or reproducibility articles; b) children/adolescents diagnosed with acute or chronic diseases, physical or intellectual disability; c) studies aiming eating disorders, injuries, bone densities, psychological issues or biomechanical issues; e) articles without access and incomplete.

Studies selection

Two reviewers (1st and 2nd author) examined independently each database. After extracting the articles from the database, it was applied the exclusion of duplicates and reading the titles and abstracts. Subsequently, the complete texts of the articles were read in full, to select possible eligible studies for this review.

Furthermore, it was conducted a search in the references of selected studies, to identify other studies for this review, not identified in the systematic search. The disagreements between both reviewers were solved in a consensus meeting. The opinion of a third reviewer (3rd author) was consulted for non-solved disagreements. The Mendeley reference manager was used to organize the systematic review.

Data extraction

The data were extracted by two independent reviewers. There were extracted information such as: authors, year of publication, country of the data, type of study, age range, sample size, objectives, assessment of the individual variables associated with performance on RG and/or assessment of an individual variable that describes the gymnast profile, assessment of performance variables on RG, main statistical analysis, summary of the results of the association with performance on RG and/or summary of the results of the individual variable that describes the gymnast profile and co-variables used in the analysis.

Risk of bias

The assessment of the risk of bias of the articles was conducted by two researchers independently (1st and 2nd author). In case of disagreement, it was required the opinion of a third researcher (3rd author). For the assessment, it was used the Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies, by National Heart, Lung, and Blood Institute (NIH)[20]. The tool criteria included inquiries that aided in the identification of possible risk of bias as to the research problem, population studied, recruited groups, eligibility criteria, sample size, assessed exposure, time-length in relation to the expected effect, interest exposure levels, measures of exposure and assessment, blindness in the assessment of the results, follow-up rate and statistical analysis[20].

To each criterium assessed, it was attributed a "yes", "no", "not reported" or "not applied". The final score was calculated based on the number of positive responses. The used calculation was the total of valid questions subtracted from the number of questions answered by "no", "not reported" or "not applied". The study score can receive whole value from 1 to 14[20] (Table 1).

RESULTS

The initial search of articles on the data bases registered a total of 431 studies. After reading the titles and abstracts, 28 articles were considered eligible for reading in full. The studies were screened and the following reasons for exclusion were identified: a) were not of RG practitioners; b) were not of beginner gymnasts; c) were not children/adolescents of age range of 6 to 19 years; d) did not present association of individual variables (biological, physical fitness or coordination) with the performance on RG or did not describe the RG practitioners' profile. Subsequent to this stage, 19 articles were excluded, remaining 9 articles. One study was identified by the citations in the studies included via databases. Overall, 10 studies were included for the descriptive summary (Figure 1).

Table 1. Assessment of methodological quality/risk of bias of the inserted studies (n=10).

Reference	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Score*
CROSS-SECTIONAL*															
Miletić et al. (2004)[21]	Y	Y	N	Y	N	Y	Y	NA	Y	N	Y	NA	Y	NR	8
Miletić & Kostić (2006)[22]	Y	Y	N	Y	N	Y	Y	NA	Y	N	Y	NA	Y	NR	8
Šebić-Zuhrić et al. (2008)[23]	Y	N	NR	Y	N	Y	NA	NA	Y	N	Y	NA	Y	NR	6
Budiarti et al. (2020)[13]	Y	N	NR	NR	N	Y	NA	NA	Y	N	Y	NA	Y	NR	5
Campos-Pérez et al. (2022)[9]	Y	N	NR	Y	N	N	NA	NA	Y	N	Y	NA	Y	NR	5
INTERVENTION WITHOUT GROUP CONTROL**															
Miletić et al. (2006)[24]	Y	Y	Y	NR	Y	Y	Y	NA	Y	Y	N	Y	-	-	9
Schemberger & Lourenço (2016)[25]	Y	N	NR	NR	NR	Y	Y	NA	Y	Y	N	Y	-	-	6
Tincea (2020)[26]	Y	Y	Y	NR	N	Y	Y	NA	Y	Y	N	Y	-	-	8
Kezić et al. (2018)[27]	Y	Y	Y	Y	NR	Y	Y	NA	Y	Y	Y	Y	-	-	10
INTERVENTION WITH GROUP CONTROL***															
Genc & Cigerci (2020)[8]	Y	N	NR	Y	NR	Y	N	NR	NR	Y	NA	NR	-	-	4

Note. Y – Yes; N – No; NR – Not reported; NA – Not applicable. *For cross-section and longitudinal studies: Q1 – Was the research question or objective of this article was clearly outlined?; Q2 – Was the population of this study clearly specified and defined?; Q3 – Was the population rate of the eligible persons at least 50%?; Q4 – Were the selected or recruited individuals of the same population or similar (including the same time-length)? Were the inclusion and exclusion criteria of the study pre-specified and applied evenly among the participants?; Q5 – Was there a justification for the sample size, power description or variance and effect estimative?; Q6 – For the analysis of the article, were the interest exposures measured before the measurement of the results?; Q7 – Was the deadline enough to reasonably expect an association between exposure and closure?; Q8 – For exposures that can vary in quantity or level, did the study examine different levels of exposure in relation to the disclosure (for instance, categories of exposure or measured exposure as a continuing variable)?; Q9 – Are the exposure measures (independent variables) clearly defined, valid, reliable and implemented consistently to all the participants in the study?; Q10 – Was the exposure assessed more than once throughout time?; Q11 – Were the measures of the result (dependent variables) clearly defined, valid, reliable and implemented consistently to all the participants in the study?; Q12 – Were the assessors of the closure blinded to the participants' exposure status?; Q13 – Was the loss of follow-up after baseline of 20% or less?; Q14 – Were the main potential variables of confusing statistically measured and fit for their impact on the relation between exposure(s) and closure(s)?; The calculation used for cross-section and longitudinal was: total of valid questions (14 questions) subtracted the number of with answers "no", "not reported" or "not applied". **For intervention studies without group control: Q1 – Was the question or objective of the study clearly defined?; Q2 – Were the eligibility/selection criteria for the population of the study pre-specified and clearly described?; Q3 – Were the participants of this study representative of those who would be eligible for the test/service/intervention in the general or clinic population of interest?; Q4 – Were all the participants who fulfilled the pre-specified entrance criteria registered?; Q5 – Was the sample size large enough to provide confidence in the results?; Q6 – Was the test/service/intervention clearly described consistently applied on the population of the study?; Q7 – Were the closure measures pre-specified, clearly defined, valid, reliable and consistently assessed on all participants of the study?; Q8 – Did the responsible persons for assessing the results blind the participants' exposures/interventions?; Q9 – Was the loss of follow-up after the beginning of the study of 20% or less? Were these follow-up losses accounted in the analysis?; Q10 – Did the statistical methods examine the changes in the measures of the result before and after the intervention? Were statistical tests which provided p values for pre-post changes conducted?; Q11 – Were the interest result measures taken several times before the intervention and several times after the intervention (that is, did they use an interrupted time series design)?; Q12 – If the intervention conducted at a group level (for instance, an entire hospital, community, etc.) did the statistical analysis take into account the use of data at an individual level to determine the effects on a group level? The calculation used for the intervention studies was: total of valid questions (12 questions) subtracted the number of answers "no" or "not informed". ***For intervention studies with group control: Q1 – Was the question or objective of the study clearly defined?; Q2 – Were the eligibility/selection criteria for the population of the study pre-specified and clearly described?; Q3 – Did the authors include a justification for the sample size?; Q4 – Were the controls selected or recruited from the same way or similar population who originated the cases (including the same time-length)?; Q5 – Were the definitions, inclusion and exclusion criteria, algorithms or processes used to identify the cases valid, reliable and implemented consistently on all participants of the study?; Q6 – Were the cases clearly defined and distinguished from controls?; Q7 – If less than 100% of the cases and/or eligible controls were selected for the study, were the cases and/or controls selected randomly among the eligible ones?; Q8 – Was there the use of simultaneous controls?; Q9 – Were the investigators able to confirm whether an exposure/risk occurred before the development of the condition or event that defined one participant as one case?; Q10 – Were the exposure/risk measures clearly defined, valid, reliable and implemented consistently (including the same time-length) on all participants of the study?; Q11 – Were the assessors of the exposure/risk blinded for the status of the case or control of the participants?; Q12 – Were the main potential confusing variables measured and statistically fit in the analysis? If pairing was used, did the investigators consider the pairing during the study analysis? The calculation used for the intention studies was: total of valid questions (12 questions) subtracted the questions with answers "no" or "not informed".
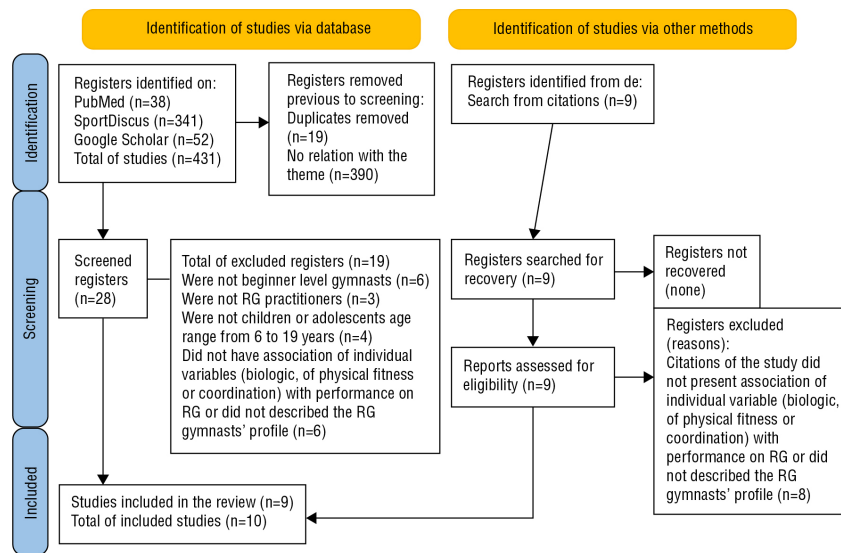
Figure 1. Flowchart of studies of association of the variables related to individual characteristics with the variable of performance on RG and/or description of RG practitioners' profile related to individual characteristics.

General characteristics of the studies

In relation to location of the studies, 8 of the 10 articles selected were carried out in Europe (Bosnia and Herzegovina, Bulgaria, Croatia, Spain, Romania, Serbia and Turkey), 1 in Asia (Indonesia) and 1 in South America (Brazil). Of all the articles, the main common characteristic was of the practitioners were of the female gender. Half of the studies adopted the cross-section type of study and half opted for the intervention type (Table 2).

In general, the studies assessed samples from 16 to 127 RG practitioners aging from 6 to 19 years. Thus, 6 studies investigated children (up to 10 years), 4 investigated adolescents (from 10 to 19 years) (Table 2).

As to purposes, the majority of the studies aimed to determine the influence of physical fitness, motor coordination and biological characteristics on performance of RG[13,21-24,27]. Three studies verified the effect of a RG specific training on the biological characteristics, on physical fitness, on motor coordination and on performance on RG[8,25,26]. And one study assessed the influence of RG practice on physical fitness and biological characteristics of gymnasts, as well as it associated the biological variables with performance of physical fitness[9] (Table 2).

In relation to risk of bias (Table 1), there were no maximum values, having the study presented a score between 4 and 10 of a total of 14. The exception is the study[27], which obtained a score of 10.

A total of 2 studies described the gymnasts' profile, 6 associated the individual variables with performance on RG and 2 described the profile and associated it with performance.

Flexibility was the most assessed variable to describe the gymnasts' profile[8,9,25,26]. Two studies also assessed the explosive strength and biological characteristics[8,9]. And one study assessed, besides flexibility, muscular endurance and balance[26] (Table 3). According to the results, the main biological characteristics that describe the beginner gymnasts' profile are low values for BMI, BF% and high stature[8,9].

Table 2. General characteristic of the selected studies (n = 10).

Authors and year of publication	Country	Type of study	Age range	Gender	Sample size	Objective
Miletić et al. (2004)[21]	Croatia	Cross-section	7 years	F	55	To establish jump performance quality and determine the influence of basic motor skills on jump by RG beginner practitioners.
Miletić et al. (2004)[24]	Croatia	Cross-section	7 years	F	50	To determine the impact of motor skills and morphological characteristics on the performance of RG motor skills of RG beginner practitioners.
Miletić & Kostić (2006)[22]	Croatia	Cross-section	7 years	F	53	To establish the performance quality of pivot arabesque and passé, and determine any probable influence of motor skills and morphologic characteristics on the performance of pivot arabesque and passé in a sample of 7-year-old girls.
Šebić-Zuhrić et al. (2008)[23]	Bosnia and Herzegovina	Cross-section	16 to 18 years	F	127	To determine the predictive values of morphologic characteristics on the performance of elements of rhythmic gymnastics without apparatus.
Schemberger & Lourenço (2016)[25]	Brazil	Intervention (pre- and post-assessment without control group)	8 to 12 years	F	54	To quantitatively verify the effect of 16 weeks of RG flexibility among beginner school gymnasts.
Kezić et al. (2018)[27]	Croatia	Intervention (pre- and post-assessment without control group)	6 years	F and M	70	To determine the influence of fundamental motor skills on the performance of RG specific skills in different motor learning stages on 6-year-old children.
Tincea (2020)[26]	Romenia	Intervention (pre- and post-assessment without control group)	6 to 8 years	F	10	To develop new training programs and stand out the existing relation between new assessment methods and sports results.
Genc & Cigerci (2020)[8]	Turkey	Intervention (pre- and post-assessment with control group)	6 to 7 years	F	16	To examine the effects of gymnastic training on certain physical and performance characteristics on 6-to-7-year-old pre-school girls.
Budiarti et al. (2020)[13]	Indonesia	Cross-section	18 to 19 years	F	82	To determine the contribution of physical condition to gymnastic basic skill.
Campos-Pérez et al. (2022)[9]	Spain	Cross-section	10 to 17 years	F	34 (24 practitioners)	To determine the influence of RG performed in different intensities by girls of prepubescent age and adolescents on (a) the physical development (through anthropometric measures) and (b) the development of physical capacity (strength and flexibility).

Note. F – Female; M – Male; RG – Rhythmic gymnastics. Description of the biological, physical fitness and motor coordination characteristics and its associations with the performance of RG beginner practitioners.

Table 3. Descriptive characteristics of the gymnasts' profile and of the association between individual variables and performance in RG (n = 10).

Author and year of publication	Assessment of the variable that describes the gymnast's profile and/or the variables associated with performance in RG	RG performance assessment	Results of the description of the gymnast's profile and/or the variables associated with performance in RG	Co-variables
DESCRIPTION OF THE GYMNASTS' PROFILE				
Schemberger & Lourenço (2016)[25]	**Flexibility** - Sit-and-reach test	-	RG practitioners of age range from 8 to 12 years presented greater flexibility (p< 0.05).	NA
Genc & Cigerci (2020)[8]	**Morphologic characteristics** - Assessment of stature (cm), sitting stature (cm), wingspan (cm), body mass (Kg), BMI, %BF, biceps cutaneous folds, triceps, subscapular, suprailiac and calf (mm), elbow and knee diameter (cm), circumference of biceps and calf (cm). **Explosive strength** - Vertical jump and long jump test. **Flexibility** - Sit-stretch test	-	EG: Stature, stature sitting and wingspan increased significantly (p< 005). %BF presented statistically significant decrease (p< 0.05). Positive influence of RG training on standing jump, long jump and flexibility (p< 0.05). EG and CG: Statistically significant increased body mass (p< 0.05). CG: Statistically significant increased BMI (p< 0.05).	Somatotype assessment
ASSOCIATION OF VARIABLES WITH PERFORMANCE				
Miletić et al. (2004)[21]	**Coordination** - Test poligon, agility; **Coordination on rhythm** - Test hand-drumming; **Movement frequency** - Test Hand-tapping and foot-tapping; **Strength** - Test sit-ups and squats; **Power** - Test standing jump test (Sargent) and med-ball-throw; **Flexibility** - Test sit-and-reach, left split and right split	**RG specific jumps with and without apparatus** - Assessment of the performance on jump through the Likert scale (1-5) after watching the material recorded on video.	Influence of coordination (coordination on rhythm, mainly) and strength (leg strength, in first place) on the performance of RG jump (p ≤ 0.05).	NA
Miletić et al. (2004)[24]	**Movement frequency** - Test hand-tapping, foot-tapping, tapping against wall; **Power** - Test standing jump (Sargent), med-ball-throw; **Strength** - Test bench standing, sit-ups, squats; **Flexibility** - Test sit-and-reach and left split/right split; **Coordination** - Test hand-drumming, hand-foot-drumming; **Morphologic characteristics:** Assessment of body mass (Kg), stature (cm), biacromial diameter (cm), fist length (cm), foot diameter (cm), abdominal circumference (cm), circumference of the upper leg (cm), triceps, subscapular and abdominal fold (mm).	**RG elements with 5 apparatus (rope, ball, bow, clubs and ribbon)** - Assessment of the performance on motor skills with the 5 RG apparatus t through the Likert scale (1-5) after watching the material recorded on video.	Flexibility (p> 0.05), explosive strength (p< 0.05) and adipose volume explain (p< 0.001) 41% of the success in the performance of RG elements (jump, spin, balance and flexibility). Frequency of movement (p< 0.001) and not adipose volume (p< 0.05) explain 26% of handling apparatus of RG (clubs, ribbon and fist ball handles).	NA
Miletić & Kostić (2006)[22]	**Morphologic characteristics** - Assessment of body mass (kg); height (cm); foot length (cm), bicristal diameter (cm); foot diameter (cm); leg circumference (cm); tricipital skinfold (mm); calf skinfold (mm). **Motor coordination** - Test Polygon backward - s. **Agility** - Side steps - s. **Movement frequency** - Test hand-tapping /15s. **Power** - Test standing jump/cm. **Strength** - Tests folded arm and sit-ups/per minute. **Flexibility** - Test shoulder flexibility/cm and sit-and-reach/cm. **Coordination on rhythm** - Test hand-drumming, hand-foot-drumming /for 20 s.	**RG Pivot Elements** - Assessment of the performance on RG pivot arabesque and passé through the Likert scale (1-5) after watching the material recorded on video.	Statistically significant multiple correlations between the morphologic and motor variables and the two tests applied to assess the performance of pivot (p< 0.05). Agility (side steps), flexibility (shoulder flexion) and adipose tissue (calf skinfold) present significant predictive value (p< 0.05) on the performance of pivot arabesque.	NA

Note. CG – Control group; EG – Experimental group; BMI – Body mass index; NA – Not applicable; %BF – Percentage of body fat; RG – Rhythmic gymnastics.

Table 3. Continued...

	DESCRIPTION OF THE GYMNASTS' PROFILE		
Author and year of publication	**Assessment of the variable that describes the gymnast's profile and/or the variables associated with performance in RG**	**RG performance assessment**	**Results of the description of the gymnast's profile and/or the variables associated with performance in RG**	**Co-variables**
Šebić-Zuhrić et al. (2008)[23]	**Morphologic characteristics** - Assessment of body mass (Kg), stature (cm), arm, hand, leg and foot length (cm), biacromial wingspan(cm), diameters of elbow, fist, bicristal, knee and hand (cm), circumferences of thorax, arm, relaxed and contracted leg and waist (cm), triceps, calf and abdominal skinfold (mm).	**RG basic elements** - Visual assessment of the execution of RG basic elements.	The variables of body mass and leg skinfold presented a statistically significant negative predictive power on the performance of RG (p< 0.05).	NA
Kezić et al. (2018)[27]	Fundamental motor skills (**Coordination**) - "Bruininks-Oseretsky Test of Motor Proficiency", second edition (BOT-2) (Bruininks and Bruininks, 2005). - Fine motor precision, fine motor integration, manual dexterity, coordination of upper limbs, bilateral coordination, balance, running speed, agility and strength.	**RG skills** - Visual assessment of the execution of the skills by experienced judges of 20 rhythmic gymnastics skill tests (5 tests for each apparatus).	Statistically significant influence of coordination on the degree of acquiring RG specific skills for all apparatus and all measurement points (p< 0.05). Bilateral coordination, lower limbs coordination, fine motor integration, manual dexterity, running speed and agility were significant predictors on the performance by RG practitioners with the apparatus rope, bow, ball and ribbon (p< 0.05).	NA
Budiarti et al. (2020)[13]	**Physical ability: Flexibility** - Test sit-and-reach. **Coordination** - Test Standing balance and agility (side step). **Explosive strength of lower limbs** - Test standing and long jump. **Muscular endurance** - Test flex-and-sit (abdominal).	**Gymnastic basic skills** - Visual assessment of the execution of gymnastical basic skills.	Physical skills have significant effect on gymnastic ability (p< 0.05).	NA
	DESCRIPTION OF THE GYMNASTS PROFILE AND ASSOCIATION OF VARIABLES WITH PERFORMANCE			
Tincea (2020)[26]	**Flexibility** - Test bridge, anteroposterior opening. **Acrobatic** - Test palm-rest side wheel, slow spin forward and slow spin backward. Balance **Specific RG balance element** - Test lateral balance with help of hand, boucle, facial plank, and panché	**RG specific balance element** - Test lateral balance with help of hand, boucle, facial plank, and panché	- Evolution on the execution of unipodal balances, muscular endurance of the back and lower limbs muscles (statistically significant increase superior to 95%). - The mobility level influences positively on the execution of balance elements.	NA
Campos-Pérez et al. (2022)[9]	**Morphologic characteristics** - Assessment of stature (cm), body mass (Kg), triceps fold (mm) and arm circumference (cm). **Flexibility** - Test sit-and-reach and shoulder rotation. **Explosive strength** - Test standing jump, long jump and 3kg ball throw	**Flexibility** - Test sit-and-reach and shoulder rotation. **Explosive strength** - Test standing jump, long jump and 3kg ball throw.	- RG practitioners presented %BF decrease, increase in explosive strength and flexibility (p< 0.01). - Height, weight, BMI, arm perimeter and arm muscle area presented statistically significant positive (p < 0.01) with explosive strength and lower limbs. Triceps skinfold presents negative correlation with long jump (p < 0.01) and standing jump (p < 0.05). Triceps-shoulder fold presents statistically significant correlation with flexibility (p< 0.05).	Trace elements

Note. CG – Control group; EG – Experimental group; BMI – Body mass index; NA – Not applicable; %BF – Percentage of body fat; RG – Rhythmic gymnastics.

In relation to the variables of physical fitness there were found high indexes for flexibility and explosive strength in comparison to non-practitioners in the post-test, as effect of a training period on RG[8,9,25]. On motor coordination, it was verified a significant evolution superior to 95% in balance ability[26] (Table 3).

To verify the association with performance, flexibility, explosive strength and muscular endurance were the most assessed variable for RG[13,21,22,24,26] followed by agility[13,21,22,27] (Table 3). Regarding the biological characteristics, body mass, triceps skinfold and stature were the main assessed measures[9,22-24] (Table 2). In relation to the motor coordination, the majority of the studies assessed the general coordination, movement frequency and balance to verify possible association with performance[13,21,22,24,27] (Table 3).

The results evidenced a positive relation between performance on RG of beginner practitioners with flexibility, explosive strength and muscular endurance on RG[13,21,22,24,26]. The values for body mass and skinfold presented a statistically negative predictive power on the success of the RG movements[9,22-24]. It is also highlighted the positive association of high levels of motor coordination and coordination on rhythm[21], as well as levels of balance and agility[12,22] with performance on RG. Still in relation to performance of practitioners with apparatus (rope, bow, ball and ribbon), bilateral coordination, coordination of lower limbs, fine motor integration, manual dexterity, running speed, agility and strength were significant predictors[24,27] (Table 3).

DISCUSSION

The present systematic review accomplished a descriptive summary of the findings of 10 studies aiming to describe the RG practitioners' profile and analyze what the variables associated to performance on RG in the SI are. It is highlighted: 1) beginner gymnasts' profile is characterized mainly by low values for BMI and BF%, high stature and high indexes of flexibility and explosive strength of lower limbs; 2) performance on RG was directly associated to individual variables, overall, for flexibility, explosive strength and muscular endurance with a positive relation; body mass and skin folds with negative power predictor; high levels of agility, balance and motor coordination; 3) the prevalence of physical fitness in the results of the studies as in the description of the gymnasts' profile as in the associations with performance; 4) existence of studies in the SI with children/adolescents; 5) half of the studies aiming cross-section studies and half aiming intervention studies; 6) low methodological quality of the studies.

RG is a sport which beauty features cause great appreciation of the public. Subsequently, the public creates stereotypes to the gymnasts' body, associating them to symmetrical, harmonic bodies, linked to a classic aesthetic[25]. Such association influences the profile of children/adolescents who seek the practice of SI on RG, justifying the results of this research in which beginner gymnasts are characterized by low values of BMI and BF%, and high stature. These are girls of initiation classes, in which the time-length of practice, differently from elite gymnasts, does not exercise such great influence on the body biological characteristics[28]. The anthropometric view of RG with characteristics of tall, thin body with long legs is considered advantageous in the beauty of the movements and on judges' judgment[24].

Flexibility is a variable that is directly associated to the RG practitioners' profile. During the warm-up of an RG class this physical fitness component is strongly developed, due to the characteristics of the sport and the requirements of the scoring code[29], which can explain, in part, such finding[25]. Flexibility on RG is identified during the wave movements, balance, pivots, jumps and acrobatics which are part of a choreographic composition. As a result, it is required that gymnasts have great flexibility to support their greater performance[30].

In addition to flexibility, the gymnasts' profile in this study evidenced high levels of explosive strength. In a certain way, this was expected, since jumping RG demand great strength of lower limbs, as well as the throwing of specific apparatus for this modality express the explosive strength of upper limbs[31]. In this sense, RG initiation programs must be aware of working all physical fitness components, which besides attending the RG demands can serve as basis for other sports in the future[32].

Concerning the association of the variables with performance on RG, flexibility and explosive strength also stand out for presenting positive associations. RG requires gymnasts with great flexibility added to a positive relation between flexibility and explosive strength[30]. In general, flexibility is linked to the execution of complex movements of great amplitude, whilst explosive strength and endurance are responsible for dynamics, speed and firmness of the gymnasts' movements[18]. As the majority of the studies in this review opted for assessing the gymnasts' performance based on RG specific elements[21,22,26,31], such variables were more evident in the results.

Low level for body mass in gymnastics is considered important to the athletes' performance in training and competitions[18,24]. Such statement corroborates with the results of this study in which the high percentage of adipose tissue has an unfavorable effect on the performance of movements in RG already in the context of beginners. This can be explained by the fact of, with the exception of one study[9], all the others[22-24] conducted tests with RG movements (balance, pivot and jump) in which the adiposity has strong impact on the quality of the execution. Such movements were assessed visually by a specialist, based on the scoring code criteria[29] which considers as failure of execution the body imbalance, the lack of lightness and amplitude in the movements. In most cases, such failures are more evident in individuals with ponderal overload. However, the practitioners' biotype should not be a limiting factor for the development of qualified practices on SI on the RG. It is known that a great number of families seek this modality exactly for its possibilities of motor development and also for weight reduction[33].

On RG, the fundamental body movements are performed with the handling of the apparatus rope, bow, clubs, ball or ribbon, which demands a high degree of motor coordination and it reflects on high levels of coordination. This corroborates with the results in this research in which it is observed that coordination presented a positive association as much on the performance of body movements as on movements with apparatus[13,21,22,24,27]. The motor skills of running, jumping, throwing, catching, balancing, spinning and landing, which are imminent skills to RG[34], are present in the coordination tests directly or indirectly, justifying such results. In addition, the handling of apparatus, mainly rope, clubs and ribbon, requires high levels of speed, agility and rhythm[24,27].

In general, the insertion of the use of apparatus happens in the categories of older girls due to its complexity of movements, in which the mastery of body elements is already a task[35]. Studies point out the importance of working RG in a broad way, focusing on the interaction between body and apparatus. In spite of obtaining a greater performance, the work of handling materials is highly motivating to practitioners and it is essential in the beginning of the learning/teaching process work[3].

Another highlight of this review is the prevalence of physical fitness in the results of the studies in the description of the gymnasts' profile as well as in the associations with performance. In a certain way, first, for the fact of the studies having opted to assess this variable and, second, for physical fitness present more significant results when compared to other biological and coordination variables. In contrast, it is important to stand out the necessity of teachers and researchers to consider motor coordination and agility as fundamental during the classes as well as in future researches, since the child may present lesser or greater ease of learning depending on the motor stage they are[36].

As a positive point in this review, it was verified studies with children/adolescents in the scope of SI in RG. From this, one can observe that the initiation becomes not only as a sports mass space, focused on the formation of future athletes and discovery of talents in childhood, but also a place of varied motor possibilities for children/adolescents[3]. Overall, considering the fact that the majority of researches in literature are generally aimed at older gymnasts focusing yield and those who have already participated in championships[37,38].

It can also be observed a prevalence of cross-section and intervention studies, which emphasizes the necessity of more research with longitudinal design which bring more subsidies to the understanding of the profile and the association of individual variables with RG practitioners in initiation groups throughout time. Long-term studies on RG, in a general way, are more focused on elite athletes in order to verify the impact of a determined variable on competitive results and the impact of specific RG[37,39].

It is noteworthy, based on the risk of bias results, that the methodological quality found did not obtain the maximum value of score. This systematic review has as limitations: (i) the majority of the studies carried out in Europe, which enables the questioning of the results of profile and association of the variables with RG practitioners' performance to beyond this region; (ii) the heterogeneity of age range of the samples and sample size, which is a challenge for the comparisons and interpretations of the results related to performance on RG among the gymnasts. In contrast, as strong points of this article stand out: (i) all articles responded to the proposed objectives; (ii) the analysis of risk of bias; (iii) the result systematization of each study, enabling precision in the understanding of the gymnasts' profile and association of individual variables with performance on RG.

CONCLUSION

The findings of 10 articles in this review evidenced as a main result the description of beginner gymnasts with low values for BMI and BF%, high values for stature, high indexes of flexibility explosive strength, motor coordination and balance. In addition, the studies pointed out low values for BMI and BF% in SI classes, as well as in high-performance classes.

As a conclusion, the main variables which have significant positive associations with performance on RG in SI are flexibility, explosive strength, muscular endurance, agility and motor coordination. Body mass and skin folds presented negative associations with performance. Taking into account the impact of variables on beginner gymnasts' performance, it is evidenced the need of working all physical and motor components, especially the motor coordination, which is characterized by the ease at learning during childhood.

Lastly, it is important to highlight that the results of the systematic review aim to facilitate the educational and sportive intervention, in a way that includes the objectives of development of each child/adolescent considering the biological, physical and motor aspects. That is how the look of sports professionals will be fit to perform in a SI that aims beyond the detection and formation of future high-performance athletes.

COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval

This research is in accordance with the standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conception, planning, analysis, interpretation and writing of the work: DFS, MCSR; Analysis, interpretation and writing of the work: DFS, MGB, MCSR.

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