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REVIEW ARTICLE

Coordination in some of the basic individual sports: a systematic review

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Abstract

The aim of this study was to conduct a systematic review of research that investigates coordination abilities in basic individual sports, such as athletics, gymnastics, climbing, and swimming. The relevant sports that have a process of identifying very young talents are precisely these basic individual sports. The following electronic databases were used: Web of Science and PubMed. A total of 16 studies met the criteria for participation in this study. Since only a few studies have been done on this topic, this review included studies for the last 30 years. The sample of respondents in the included studies consisted of both males and females, and the total number was 642. The study findings indicate that coordination is a crucial motor ability with a significant impact on athletic success in youth. The level of coordination abilities increases with sports experience, so the development of coordination should be one of the priorities in the training process of gymnasts, athletes, sports climbers and swimmers in younger sportsman ages.

Keywords: Athletics, sports climbing, sports gymnastics, swimming.

Introduction

Research on coordination abilities is closely related to research that explains how the central nervous system works. Coordination is the basic motor ability to perform complex and varied motor actions (Malacko & Rađo, 2004). Therefore, coordination has been found related to intelligence, making it a very important and demanding motor ability that should be researched (Smits-Engelsman & Hill, 2012). However, the results of the previous studies still do not provide enough data for this motor ability to be considered well researched in success in certain sports disciplines. Sports that have early specialization in their selection process are sports that belong to the group of individual sports: athletics, gymnastics, sports climbing, and swimming. Their specialization starts at the age of 7-8, and sports success is achieved around the age of 16-17, which could be said to be the period of top mastery related to the period of growing up - puberty. Each athlete undergoes an individual development period in specific sports disciplines, which results in the development of coordination abilities based on personality traits. According to Petković & Bojić (2010), coordination in sports activities can be divided into general (the ability to rationally perform various motor actions, independent of sports specialization) and specific (the ability to quickly perform various movements in a certain sport, harmoniously, easily and precisely). The specific movements in certain sports are determined by the development of coordination abilities. The process of adopting complex exercises is based on learning the specific movements of a particular sports discipline. The

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specific movements cannot be improved without perfecting specific coordination abilities in those movements. According to Petković (2017), coordination in exercises can be developed in several basic stages: performance of standard technical structures of a certain sport, performance of all exercises on the opposite side (right-handed to left and vice versa), changing elements of known techniques, adding new movements with related techniques, changes in speed and rhythm in performing exercises, increasing the load in situational exercises and learning the technical skills of other sports.

There are some studies where it has been established that coordination has a great influence on sports success and performance in gymnastics, athletics, sport climbing and swimming (Pavić et al., 2016; Petković, 2004; Stanković et al., 2019; Sterkowicz et al., 2014; Vandorpe et al., 2012). Also, it is considered that the priority of developing coordination abilities should be in the training process itself in order to reach the highest load values (Belej & Junger, 2006). Furthermore, it has been established that athletes with more sports experience have better coordination and perform sports tasks more easily (Gautier et al., 2009). Also, it can be considered that children who are involved in the IAAF Kids' Athletics project have better coordination abilities than those who did not participate in sports events (Čillík & Willwéber, 2018; Petros et al., 2016).

Coordination, as one of the important motor ability, affects success and needs to be defined: through the growth stages of the individual and the degree of difficulty of adopting the coordination movement. Individual sports often require early specialization, making them engaging topics of discussion. The importance that basic individual sports such as gymnastics, swimming, athletics and sport climbing have on athletes success should be investigated. Therefore, the aim of this study was to conduct a systematic review of research that investigates coordination abilities in basic individual sports, such as athletics, gymnastics, climbing, and swimming.

Methods

The Literature Identification

Studies were searched and analyzed by the electronic databases. For this study databases Web of Science and PubMed were used to collect relevant literature. According to the authors' interests, 4 sports were chosen for discussion: athletics, sports gymnastics, sports climbing and swimming. The chosen sports are basic for the development of the coordination abilities of young athletes. These sports have an early specialization and selection process, where athletes achieve high level results during puberty. The research strategy is presented in Table 1.

Table 1
Search strategy to identify articles.

Search 1	Search 2
Coordination	Gymnastics
Motor Ability	Swimming
Motor Control	Sports Climbing
	Track and Field
	Athletics

Descriptive method, method of systematization and analysis were used for the purposes of this study. Studies were carefully analyzed and identified as suitable for participation in this study based on titles, abstracts and full papers. The literature search was performed by the authors. Next, each author cross-identified the studies. Finally, the study was either rejected or accepted for further analysis.

Inclusion Criteria

Studies had to meet the following criteria for detailed analysis. The first criterion was related to the fact that the studies contain the development of coordination, which means that all studies that deal with the development of some other motor ability were excluded. The second criterion was that the studies focused on individual sports such as athletics, sports gymnastics, spots climbing and swimming. The third criterion was that the studies had been published since January 1990. The fourth criterion was that the studies were published in English, and the final criterion was that all studies were original. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) standards were used (Page et al., 2021). The method of data collection is presented in Figure 1.

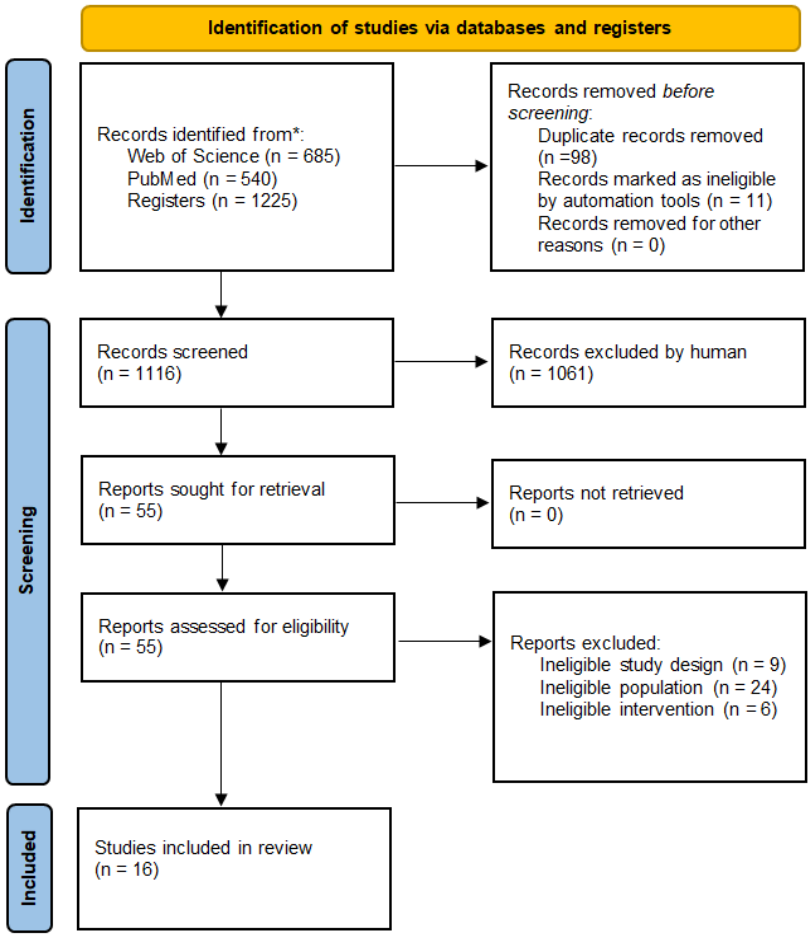

Figure 1. PRISMA flow diagram.

Risk of Bias Assesment

Two authors (S.M. and A.S.) independently assessed the study's quality and suitability for inclusion in the final analysis. The obtained data was assessed by a third author (E.P.), who had the final say in cases of disagreement over the conclusions regarding the assessment of the risk of bias.

Results

Sixteen studies were presented in Table 2. The table contains information about the first author and year of publication, the sample of respondents, type of sport, coordination variables and results of the study.

Table 2 shows the information from 16 studies that corresponded to the given topic. The oldest study was published in 1996 (Robertson, & Elliott, 1996), while the most recent study was published in 2019 (Stanković et al., 2019). The sample of respondents consisted of both females and males, while in six studies the sample of respondents was only female (Kochanowicz et al., 2009; Marin et al., 1999; Potop 2013; Robertson, & Elliott, 1996; Stanković et al., 2019; Vandorpe et al., 2012). The total sample of respondents in all studies was 642. The largest number of respondents was 232 (Petros, et al., 2016), while the smallest number of respondents was nine (Potop 2013). The oldest respondents were between 18-25 years old (Schnitzler et al., 2007), while the youngest were between 5-7 years old (Ćacan et al., 2016). Namely, in all studies, it has been proven that coordination plays an important role in sports success as well as in the performance of sports techniques.

Table 2
Analysis of the included studies.

First Author and Year of Publication	Sample		Sport Type	Variables	Results
	Number	Age			
Robertson et al., (1996)	F = 20	19-23	G	CEB	C↑
Marin et al., (1999)	F = 16	19-22	G	TTHFW, TTHF	PC↑
Petković (2004)	N = 58	7-9	G	POLD, POLB, LSJM,HMEP, HMSP, ARHD, SWAH, DJAE, MEAH, VAU, BAR, BAL, FLR, AAC	SCM↑ SRC↑
Seifert et al., (2007)	N = 42; F = 12; M = 30	17-23	S	IdC	aC↑
Schnitzler et al., (2007)	N = 12; F = 6; M = 6	18-25	S	ECH, PP, PUP, RP	aC↑
Gauthier et al., (2008)	N = 16	x	G	H20	C(HE)↑ C(IE)↑
Kochanowicz et al., (2009)	F = 18	7-9	G	ET, FLB, GC	C↑
Vandorpe et al., (2012)	F = 23	7-8	G	KTK	C↑
Potop (2013)	F = 9	12-14	G	DJ, BT, SB	DJ↑ BT↑ SB↑
Sterkowicz et al (2014)	N = 25	x	SC	CMA	C↑
Issa (2016)	N = 36	12-14	G	CAT, GEF	C↑
Ćaćan et al., (2016)	N = 34; F = 14; M = 20	5-7	S	RSJ, JJ, SJJ	C↑
Petros et al., (2016)	N = 232; F = 123; M = 109	10-12	A	EB	C↑
Pavić et al., (2016)	F = 35	10-12	A	SLJ, TM, S20, SA, JR, BP, SM, FB, R	C↑
Čillík et al., (2018)	N = 55; F = 16; M = 39	6-7	A	SLJ, TM, RJ, S20, RSL, SB	C(E)↑
Stanković et al., (2019)	F = 11	15-17	SC	POLB, KOPA, 20IP	C↑

Legend: ↑ - statistical significance; x – no information; N – number of respondents; F –female respondents; M – male respondents; C – coordination; G – gymnastics; S – swimming; A – athletics; SC – sports climbing; PC – postural coordination; CEB - more complex coordination exercises on the beam; TTHFW - tracking the target with the head fore-aft without instructions; TTHF - tracking the target with the head fore-aft with instructions; POLD - the skill polygon, the more difficult version; POLB - the backward polygon; LSJM - 10 × 4 lying down, squatting and jumping; R2 × 15 - running 2 × 15 m from a lying start; HMEP - hand motions in the frontal plain; HMSP - hand motions in the sagittal plain; ARHD - arrhythmic hand drumming; SWAH - somersault exercises and walking a line accompanied by asymmetrical hand motions; DJAE - depth jump exercises, accompanied by asymmetrical "activities" of the extremities; MEAH - movement exercises accompanied by asymmetrical hand motions; VAU - vault with a forward approach with a flip in post-flight into a standing position on the mat; BAR - uneven bars; BAL - balance beam; FLR - floor exercise; AAC - the total amount of all the scored points for each of the individual disciplines; SCM - execution speed of complex motor tasks; SRC - second for rhythmic coordination; H20 - handstand for 20s or more; HE - high expertise; IE - intermediate expertise; ET -ellipsis test; FLB - flamingo balance test; GC - global coordination test; SS - swimming start; ST - swimming turn; CST - crawl swimming technique; BST -breaststroke swimming technique; BCST - backstroke swimming technique; BTST - butterfly swimming technique; KTK - Körperkoordinationstest für Kinder; RSJ - Bilateral Motor Coordination Test; JJ - Bilateral Motor Coordination Test; SJJ - Bilateral Motor Coordination Test; SLJ –standing long jump; TM - throwing a medicine ball; S20 - 20m sprint; SA - step aside; JR - jump rope; BP -backward polygon; SM - shoulder mobility; FB - forward bend; R - resistance; RJ - rhythmic jumps on the outer part of the line with the help of a metronome; RSL - reaction speed of the lower limbs; SB - static balance; E – experimental group; IdC – index of coordination; cA – arm coordination; ECH - entry and catch of the hand in the water; PP - pull phase; PUP - push phase; RP -recovery phase; EB - Eurofit Battery; KOPA - coordination with a baton; 20IP - 20 steps with a baton; CMA -computer tests of motor abilities; CAT – coordination ability test; GEF - gymnastics for all evaluation form; DJ - depth jump from the high bar; BT - "Briuk" test.

Discussion

The aim of this study was to conduct a systematic review of research that investigates coordination abilities in basic individual sports, such as athletics, gymnastics, climbing, and swimming. It has been established that elite gymnasts and gymnasts with a longer sports career overcome sports problems more easily than gymnasts with less sports career and experience (Robertson & Elliott, 1996; Gautier et al., 2009). There is also an influence of head movement on postural coordination during beam exercise in elite and recreational gymnasts (Marin et al., 1999). Namely, using the canonical correlation analysis, the relations of situational-motor coordination with competitive success in sports gymnastics were established. Also, it is possible to interpret situational-motor coordination that is responsible for the general success within the two-dimensional structure of competitive success of gymnasts (Petković, 2004). Because the coordination is significantly defined by all the variables for evaluating the success of performing short sets on individual apparatus (Floor exercises, Balance beams, Parallel bars and Vaults) and the all-around competition (Petković, 2004). The development of coordination abilities should be a priority in the modern sports training of gymnasts (Belej & Junger, 2006). More precisely, quality evaluations of coordination and motor abilities create the basis for the individualization of training programs for gymnasts in the initial phase (Kochanowicz et al., 2009). According to Vandorpe et al., (2012), coordination was found to be the only valid criterion within a battery of predictive tests for success in sports gymnastics. Furthermore, Issa (2016) showed the presence of statistically significant differences between pre and post measurements for coordination abilities and some elements of Gymnastics for all shows' performance levels in favour of post measurement. The study recommended to give concern to develop coordination abilities on different teams (boys, girls and mixed) (Issa, 2016). Potop (2013) considered that the assessment of sensory-motor coordination, consistent with the biomechanical analysis of the key elements of sports technique, would highlight their influence on technical training and the performances achieved in competition. The study was on a group of 9 junior female gymnasts 12 to 14 years old, members of the Olympic team of juniors of Deva. The results of the study highlight the development of sensory-motor coordination in terms of spatial-temporal coordination, balance and vestibular coordination; kinematic and dynamic analysis of the key elements of sports technique regarding the trajectories of body segments, the angular speeds and the momentum of force in the backward giant with handstand 360º twist on uneven bars (Potop, 2013).

Furthermore, coordination is a motor ability which is very important and essential for success in sport climbing (Stanković et al., 2013). Also, it is considered that climbers with more developed coordination are more successful in this sport than those with less developed coordination (Stanković et al., 2019; Sterkowicz et al., 2014). It can be said that coordination in sport climbing refers to a superior perception of climbing possibilities; optimization of spatio-temporal functions related to the coordination of the body on the wall (rock), the climbing trajectory and the hand-grip surface ratio; and minimizing minimisation of exploratory behavior (Orth et al., 2016). The improvement of coordination is related to the difficulty of the climbing direction and the level of individual abilities. Also, perceptual and motor adaptations that affect coordination are very important for improving climbing abilities (Orth et al., 2016).

The development of coordination in elite swimmers is realized on a daily basis within the training of swimming technique elements. Arm coordination in young swimmers is developed through exercises during training and perfecting a certain swimming technique (Schnitzler et al., 2007; Seifert et al., 2007). Also, there are significant gender differences as well as the correlation between the difficulty of the bilateral motor coordination test and the swimming performance time (Ćaćan et al., 2016). Chollet et al., (2000) have analyzed stroke phases and the coordination of arms and legs during front crawl swimming. Forty-three swimmers constituted three groups based on performance level. The different stroke phases and the arm and leg coordination were identified by video analysis. Arm coordination was quantified using a new index of coordination (IdC), which is based on the lag time between the left and right arm propulsive phases. The most important results showed that the duration of the propulsive phases increased significantly with increasing velocity: The arm and leg synchronization was modified in the sense of an increase in a six-beat kick (Chollet et al., 2000). Seifert et al. (2014) have updated the understanding of inter-limb coordination in swimming to analyse the relationship between coordination variability

and stability in relation to interacting constraints (related to task, environment and organism) that swimmers may encounter during training and performance.

According to Pavić et al., (2016), there is a connection between morphological and motor characteristics and success in athletic disciplines. It has been proved that coordination had a greater influence on success in athletics than morphological characteristics in girls aged 10 to 12 (Pavić et al., 2016). Furthermore, explosive power, agility, and coordination were identified as essential variables for success in both throwing disciplines (Vortex throw and ball throw), which was expected considering the similarities in movement structure (Pavić et al., 2016). It has also been established that children who are involved in the IAAF Kids' Athletics project have greater improvements in coordination performance compared to those who are not (Čillík & Willwéber, 2018; Petros et al., 2016). The IAAF Kids Athletics program is a successful strategy that can be used in physical education, offering physical educators another way to improve the effectiveness of their lesson (Petros et al., 2016). This can be verified by the program's impact on children's motivation and intention to participate in sports in an organized atmosphere (Petros et al., 2016).There are not many published scientific papers that have investigated the coordination in athletics. Considering that athletics is one of the most important basic sports, further study of coordination within this sport is necessary. Because of all mentioned above, it can be said that the development of coordination in these basic individual sports is very important in order for athletes to achieve the best possible sports success. One of the priorities of coaches should be the development of athletes' coordination during the implementation of the training program.

Conclusion

Based on the collected studies and their systematization, the following could be concluded: sports gymnastics - there is a significant influence of coordination on success in gymnastics and coordination performance improves with experience in the sport. Therefore, one of the priorities in the training program should be the development of coordination. The following factors were obtained: the ability to accurately perform complex motor tasks, agility, the ability to manage movements in the shoulder joint, rhythm and speed of complex motor tasks; sports climbing - one of the important factors that affect success in sport climbing is coordination. Perceptual and motor adaptations improve coordination. They also play a role in improving climbing skills; swimming - a significant correlation between the test of bilateral motor coordination and success in swimming was established. Coordination is not developed separately, but during the improvement of swimming techniques; athletics – coordination appears as an essential motor ability tested along with speed, explosive power, agility etc. Also, it has been established that children, who trained athletics at a younger age, had more developed coordination.

Authors' Contribution

Study Design: EP, DS; Data Collection: FNS, SM; Manuscript Preparation: AS, SM; Funds Collection: AS, EP.

Ethical Approval

No ethical approval is required.

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Conflict of Interest

The authors hereby declare that there was no conflict of interest in conducting this research.

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