

The impact of coordinative abilities on the development of self-regulated Learning

MIRELA MÜLLER,¹ GORDAN DRAŠINAC², DAMJAN JAKŠIĆ³,

¹Department of German Language and Literature, Faculty of Humanities and Social Sciences, University of Split, Poljička cesta 35, 21000 Split, CROATIA,

²University Department of Professional Studies, University of Split, Kopilica 21, 21000 Split, CROATIA

³University of Novi Sad, Faculty of Sport and Physical Education, Lovčenska 16, 21000 Novi Sad, SERBIA

Published online: January 31, 2025

Accepted for publication: January 15, 2025

DOI:10.7752/jpes.2025.01011

Abstract

Contemporary, recent research implicitly indicates the importance of the role of coordination abilities that can positively affect the learning process. While today there are various scientific studies on the relationship between motor abilities and cognition, there is a lack of research regarding the influence of certain degrees of coordination abilities on the development of a self-regulated learning process. Self-regulated learning is a type of learning in which students direct themselves during learning and transform their mental abilities into learning skills. Given that the effect of different analyzers (kinesthetic, tactile, static-dynamic, optical, acoustic) can have a decisive influence on the quality of coordination abilities. Given that the effect of different analyzers can have a decisive influence on the quality of coordination abilities, this paper will examine students' perceptions of the degree of connection of motor or sports abilities to the development of the self-regulated learning process. The paper starts from the main hypothesis of the research, whereby, by examining the student's perception, it would try to point out the connection between the degree of development of the coordination abilities of physical activities and the development of self-regulated learning. The online survey was conducted in the period from May 25 to June 15, 2023, among students of two faculties in Split (University of Split, with three majors: University Department for Professional Studies majoring in Computer Science, Department of Forensic Sciences, and Faculty of Kinesiology in Croatia) and Novi Sad (University of Novi Sad, Faculty of Sport and Physical Education, Serbia). Overall 120 students participated in this study. In coordination-oriented courses, no differences were found between coordination capacities in free time and coordination capacities during regular studies. Students of both groups, the Coordination-oriented, and Other course groups agree that the quality of coordination abilities influences the learning process ($\chi^2=1.33$; $p=0.51$). In another course, group of student's differences was found between coordination capacities in free time and coordination capacities during regular studies for synchronization ($Z=2.03$; $p=0.04$), rhythm ($Z=2.47$; $p=0.01$), orientation ability ($Z=2.67$; $p=0.01$) and reaction capacity ($Z=2.57$; $p=0.01$). The paper tries to point out some of the teaching strategies used in physical activities and practical exercises as part of regular higher education classes, which can encourage self-directed learning of movement and thus develop parallel degrees of coordination ability. Descriptive and inferential statistics data processing will be performed through SPSS. The research indicates possible differences and/or correlations among students about dependent and independent variables.

Keywords: coordination abilities, physical activity, learning and teaching strategies, self-regulated learning, student success

Introduction

Effective teaching and learning are prerequisites. Self-directed learning combines will, knowledge, and ability (Hirtz, 2007; Lutz, 2010). The question arises: Why was research on the topic of coordinative skills and self-regulated learning necessary? The answers can be found in several explanations, linking to previous similar research (Rusell et al., 2020; De Smil et al., 2018; Hattie, 2015; Zimmermann, 2000). Research on the topic of coordinative abilities and self-regulated learning is important for several reasons. Coordinative abilities, which include the physical and mental abilities necessary for the efficient management of body movements and problem-solving strategies, are crucial for development in both physical and cognitive terms (De Smil et al., 2018). Self-regulated learning, on the other hand, refers to an individual's ability to actively manage their learning – setting goals, monitoring progress, and adjusting strategies according to needs (Hirtz, 2007). Learning about these aspects can contribute to a better understanding of how people learn and develop, but also how results in education and physical training can be improved. For example: a) The link between coordination and learning - Research can help better understand how physical coordination skills can improve concentration, memory, and problem-solving abilities (Cho&Heron, 2015); b) Self-regulation in learning – Understanding how people self-regulate their learning can be useful for developing educational strategies that help students become

more efficient and motivated (McDonald, 2019), and c) Improvement of educational methods - The results of such research can contribute to the development of methodologies that better integrate physical and cognitive aspects of learning, making educational processes more efficient (Hirtz, 2007). Support in therapies and rehabilitation - Research can be useful in the context of rehabilitation or therapeutic methods, especially when it comes to restoring coordination abilities or encouraging self-regulation in learning in people with different types of impairments or disorders (Rosenkötter, 2013). Given the simultaneous and ongoing boom in "self-organization" in almost all areas of society and especially in "self-organized, self-controlled, self-determined learning", there is uncertainty among teaching staff. Self-activity in learning is the order of the day. To put it bluntly, one could ask: Can and should teaching still exist at all? And: How can it be carried out? (Winter, 2007). Under these circumstances, self-determination in learning degenerates into instrumentalist receptologies and becomes a purely methodological concept.

The aim is then to create the illusion of participation and cooperation in the learning process through increasingly sophisticated learning arrangements (Winter, 2007). In this respect, the variety of methods so often assumed to be exemplary can also be seen as self-instrumentalization (Walk, 2011). The learner must be willing and able to plan, carry out, and evaluate learning independently and on his or her responsibility (Posner, & Snyder, 1975; Zimmerman, 2000). For students to be able to organize their learning independently, they need a range of skills that cannot be assumed from the start (Pashler & Johnston, 2007).

Students must not only be able to set goals for themselves and plan the necessary learning steps but must also have a repertoire of learning skills (such as effort, time, and knowledge management) and be able to evaluate their learning progress (Spitzer, 2002). To help your students develop these skills, it is helpful to focus on the characteristics of a good learner (Bahri et al., 2022). Students who learn well: a) are good at setting their own goals; b) can self-reflect; d) can make good use of their prior knowledge; e) adapt their learning strategies to subject-specific circumstances, check their learning progress regularly, and f) can motivate themselves again and again (Cho & Heron, 2015). Reflecting on your thinking and knowing about your knowledge is crucial for a successful learning process (Cleary et al., 2017). Sport is very important in training the students' metacognitive skills and encouraging them to reflect on themselves (Concannon et. Al., 2018).

Coordination skills during physical activities are important for self-directed learning (De Smul et al., 2018). Motor skills and movement are directly related to learning (Araújo et al., 2018). Motor development and motor learning therefore involve changes in motor functions. Motor development affects longer periods (years, decades, life course) (Araújo et al., 2020). The motor centers control all fine and gross motor movements. These conscious movements are referred to as voluntary motor skills (Demetriou et al., 2015). Learning takes place in the brain, but the body acts as a means of transporting the knowledge to the brain. The cooperation between the body and the brain takes place in the central nervous system (CNS) and takes place via the sensory organs (Rusell et. Al., 2020). Discovery learning and social and cooperative learning are inseparable (McDonald, 2019). Quality development of teaching through self-directed learning is the general question today. Cognitive researchers and developmental psychologists like Piaget (1973a) have made us aware that a person's cognitive development starts from sensorimotor experiences and then - in constant exchange with these - gradually develops beyond them. "The clearest result of genetic research is (. . .) the insight that rational thinking is an arrival point in the development of the subject and not a starting point. Reflective and conceptual intelligence is preceded by practical and sensorimotor intelligence, which itself continues the development of perception and motor skills." (Bai et al., 2022, p. 45).

Thinking and acting take place in a sequence of five stages: grasping, comprehending, operating, understanding, and developing. In everyday dealings with the demands of the environment, these stages of thinking and acting are less clearly differentiated than this sequence of steps - formulated for analytical reasons - might suggest (Black, & Deci, 2000). Motivational-volitional strategies of self-regulation help to set realistic goals and pursue them with effort and perseverance (Hattie, 2015). Sport affects the physical, psychological, and social resources of a person (Rheinberg, 2010). In this context, the term resource refers to characteristics of the behavioral repertoire that are available to an individual to be able to cope with sporting demands (Sibley & Etner, 2003). Physical resources are generally referred to as motor skills (speed, strength, endurance, coordination, and flexibility) (Piaget, 1973a; Sindeler, 2004). Long-term sporting activities can be associated with the reduction of excessive body weight or have a preventive and therapeutic effect against sports injuries (Rosenkötter, 2013). Because of the already recent expressions, it was the motivation for this research issue.

Materials & methods

Participants

Descriptive data are summarized in Table 1. Overall 120 students participated in this study. Fifty-four percent (54%) of participants are from the Department of Professional Studies (Computer Science) and the Department of Forensic Sciences, and 46% are from Physical, and Health Education University of Split, and the University of Novi Sad. Furthermore, most of the students are second-year students (57.1%), mean age ($\pm$ sd) 22.0 $\pm$ 3.32. Almost equal numbers of female (53.3%) and male (46.7%) students participated.

Table 1 Subjects descriptive data (N=120)

Study course (n, %)	
Department of Professional Studies	40, 33.3 %
Department of Forensic Sciences	25, 20.8 %
Physical, and Health Education University of Split	7, 5.8 %
Physical, and Health Education University of Novi Sad	48, 40.0 %
Year of study (n, %)	
1.	26, 21.8 %
2.	68, 57.1 %
3.	19, 16.0 %
4.	4, 3.4 %
5.	2, 1.7 %
Gender (n, %)	
M	56, 46.7 %
F	64, 53.3 %
Age (mean±sd)	22.0±3.32
High (mean±sd)	176±10.2
Weight (mean±sd)	72.4±15.1

Note: M-men, F-female, sd –standard deviation

Study protocol:

The authors of the study from the aforementioned institutions contacted the students and informed them about the importance of the study and the protocol. They were informed that participation was voluntary and that there would be no intention to link the answers to specific individuals. The testing was planned and held during 2023, i.e. from May 25 to June 15., and practically all students who voluntarily participated in completing the online questionnaire agreed to complete the online questionnaire. Participants were informed that they should answer all questions honestly and without hesitation and that the questionnaire was anonymous. Variables: Variables were collected through previously validated questionnaires, and in this study, they included sociodemographic variables as well as self-report factors.

Organization of Research and Instrument:

The online survey was conducted in the period from May 25 to June 15, 2023, among students of two faculties in Split (University of Split, with three majors: University Department for Professional Studies majoring in Computer Science, Department of Forensic Sciences, and Faculty of Kinesiology in Croatia) and Novi Sad (University of Novi Sad, Faculty of Sport and Physical Education, Serbia). A total of 120 students were examined. The following Likert scale was used to examine individual parameters related to self-assessment of motor ability: 1 -excellent, 2-above average, 3-average, 4-below average, 5 bad, and 6 very bad. The degree of significance was used for the evaluation, i.e. examination of the physical-motor ability of the examinee (this applied to the question related to the successful performance of practical exercises of physical activities). The degree of importance consisted of a 5-point Likert scale (1-very important, 2-important, 3-moderately important, 4-slightly important, and 5-not important). The online questionnaire had a total of 17 questions and consisted of 3 sections. The first section, which, in addition to general information about the respondents (age, gender, field of study, academic achievements, anthropoid morphological indicators: body height and body weight), also contained questions about coordination capacities. For each type of capacity, the respondents had to choose the degree of importance of how often they used them in some of the extracurricular activities in their free time. This was measured using a 5-point Likert scale (1-never, 2-rarely, 3-occasionally, 4-often and 5-very often). Also, in the first section of the online questionnaire, respondents were required to select the level of importance for each type of coordination capacity, and how often they used it in some of the active physical practical exercises during regular studies! In the first section of the online questionnaire, respondents were asked to assess their motor skills. For each parameter and type of sport, they entered their self-assessment of motor skills. They also indicated the degree of importance of each physical-motor ability for successfully performing practical physical activity exercises. The second (2) section of the online questionnaire contained questions related to mental rotation training! MacDonald (2019) defines mental rotation as a continuous transformation of the orientation of the mental image. Mental rotation is often implicated for scientific purposes as a key factor in the success of self-regulated learning. Spatial-cognitive training is a subtype of sweeping rotation training and is often used in medical-psychological research as relaxation training and better memory training. One of the important questions was in which type of physical activity content during practical exercises they considered mental rotation training to be used. For each content, they selected the level of use. The third (3) section of the online questionnaire was about self-regulated learning. Self-regulated learning occurs through three learning phases: 1) before learning (students analyze the task, set goals, plan learning strategies, and define motivational beliefs (self-efficacy, outcome expectations, intrinsic interest, task value, goal orientations); 2) during learning (students

self-monitor) and 3) after learning (self-reflection on learning and learning outcomes) (Zimmerman, 2000). In this third section of the online questionnaire, very important questions were asked, such as: Do respondents believe that more frequent physical activity can help them develop an active process of self-regulated learning?; What type of physical-motor ability do they think can help them the most in the self-regulated learning process?; Do the respondents think that the higher your level of development of coordination abilities of physical activities, the greater the possibility of acquiring the theoretical material of a teaching subject (better concentration for learning, etc.)? For a meaningful connection of self-regulated learning to how the coordination ability of physical activities can help; respondents had the option of selecting multiple answers: In the pre-learning phase, in the during-learning phase, in the post-learning phase, and all of the above response options. The online questionnaire also contained open-ended questions, such as a question regarding what types of training the respondents would like to have more intensively in practical exercises during their studies to encourage the process of self-regulated learning.

Statistical analysis

Statistical Analysis. To determine descriptive frequency characteristics and perform initial statistical operations, the computer program “IBM SPSS Statistics” version 29.0.0.0 (241) was used. The initial empirical results were automatically entered into Google Forms, then they were transferred to the matrix of empirical data in “MS Excel”. To visualize the research data, the graphical editor “MS Word” was used. The statistical levels of $p \leq .050$; $p \leq .010$ and $p < .001$ were considered to be significant. Several standard unified statistical coefficients were employed. Shapiro-Wilk normality test was used to validate the assumption of normality and showed departs from a normal distribution. Mean value comparisons between relevant variables were carried out using Mann Whitney U test and chi-square test (χ^2). Descriptive statistics of relevant measures were summarized by N, percentage, mean, and standard deviations.

Research hypotheses

The research had three research hypotheses: H¹ It is assumed that a certain degree of coordination abilities, motor skills, practical exercises of physical activities, and mental rotation training will influence the development of a self-regulated learning process; H² Students of coordination-oriented courses like Physical, and Health Education University will estimate the influence of the coordination abilities, motor skills, practical exercises of physical activities and mental rotation training benefits higher in developing a self-regulated learning process, and H³ Students from two groups of courses will estimate differently the helpfulness of self-regulated learning phases on coordination abilities.

Results

Overall 120 students participated in this study. In coordination-oriented courses, no differences were found between coordination capacities in free time and coordination capacities during regular studies (Table 2). In another course group of students differences were found between coordination capacities in free time and coordination capacities during regular studies for synchronization ($Z=2.03$; $p=0.04$), rhythm ($Z=2.47$; $p=0.01$), orientation ability ($Z=2.67$; $p=0.01$) and reaction capacity ($Z=2.57$; $p=0.01$).

Table 2 Differences in coordination capacities in free time and during regular studies

		Coordination capacities in free time		Coordination capacities during regular studies		Test	p
		Mean	sd	Mean	sd		
Coordination-oriented (N=55)	The ability to distinguish	3.24	0.84	3.13	0.86	0.63	0.53
	Synchronization ability	3.18	0.70	3.22	0.84	-0.56	0.57
	Rhythm ability	2.78	0.98	2.89	0.85	-0.53	0.59
	Balance ability	3.22	0.71	3.07	0.84	0.74	0.46
	Adaptation ability	3.11	0.71	3.27	0.78	-1.25	0.21
	Orientation ability	3.35	0.70	3.20	0.76	0.91	0.36
Other course (N=65)	Reaction capacity	3.38	0.71	3.25	0.75	0.82	0.41
	The ability to distinguish	2.94	0.83	2.60	0.98	1.91	0.06
	Synchronization ability	2.85	0.83	2.52	0.94	2.03	0.04*
	Rhythm ability	2.77	1.04	2.28	1.10	2.47	0.01**
	Balance ability	2.95	0.91	2.71	1.01	1.29	0.20
	Adaptation ability	2.77	0.96	2.65	0.94	0.67	0.50
	Orientation ability	3.11	0.92	2.62	1.03	2.67	0.01**
	Reaction capacity	3.22	0.81	2.75	0.99	2.57	0.01**

Note: * - $p < .05$; ** $p < .01$

Furthermore, differences between Coordination-oriented and Other course groups were found in some of the motor skills (Table 3). Students in the Coordination-oriented group have a significantly higher maximal number of push-ups ($Z=2.89$; $p<0.001$) and reel backward ($Z=2.09$; $p=0.04$) than students in the Other course group. In the context of the subject didactics of the subject of physical education and sport, psychological questions are of central importance (Spitzer, 2002).

Table 3 Differences in motor skills between Coordination-oriented and Other course groups

	Coordination-oriented N=55		Other courses N=65		Test	p
	Mean	sd	Mean	sd		
Long jump from place	3.70	0.74	3.57	1.05	0.45	0.65
The maximum number of push-ups in 10 seconds	3.75	1.02	3.06	1.32	2.89	0.00**
Running	3.65	0.84	3.28	1.08	1.80	0.07
Swimming	3.29	1.01	3.51	0.99	-1.18	0.24
Agility	3.76	0.87	3.62	0.85	0.99	0.32
Diving	3.18	1.26	3.06	1.25	0.18	0.86
Mountain climbing	3.20	1.00	3.38	1.16	-0.79	0.43
Reel ahead	4.07	0.94	3.69	1.07	1.79	0.07
Reel backwards	3.98	0.97	3.50	1.15	2.09	0.04*
Coordination with the ball (foot-hand)	3.91	1.02	3.66	1.16	1.05	0.30

Note: * - $p<0.05$; ** $p<0.01$

Students were also asked to estimate how successfully they performed practical exercises of physical activities (Table 4). Strength differences between the Coordination-oriented and Other course groups were found ($Z=2.42$; $p=0.02$). Students in the Coordination-oriented group estimate their strength as higher.

Table 4 Differences in estimates of practical exercises of physical activities performance between Coordination-oriented and Other course groups

	Coordination-oriented N=55		Other courses N=65		Test	p
	Mean	sd	Mean	sd		
Strength	3.38	0.71	3.05	0.70	2.42	0.02*
Speed	3.22	0.79	3.08	0.78	0.96	0.33
Endurance	3.53	0.66	3.56	0.61	-0.13	0.90

Note: * - $p<0.05$; ** $p<0.01$

Students were then asked to estimate what type of physical activity content they would benefit from mental rotation training (Table 5). Differences between the Coordination-oriented and Other course groups were found in two activities – movement exercises ($Z=2.03$; $p=0.04$) and repetition exercises ($Z=2.39$; $p=0.02$). For these two activities, higher estimates were for the coordination-oriented group.

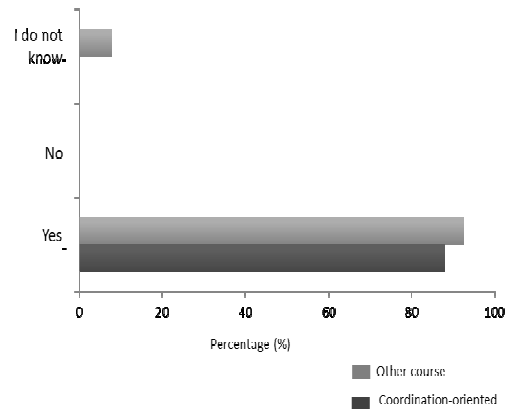
Table 5 Differences in estimates of mental rotation training benefits between Coordination-oriented and Other course group

	Coordination-oriented N=55		Other courses N=65		Test	p
	Mean	sd	Mean	sd		
Elements and tightening exercises	2.74	0.94	2.49	0.79	1.56	0.12
Rolling movement exercises ¹	2.44	1.07	2.48	0.94	-0.17	0.86
Exercises related to the support of grasping hands and rolling over	2.65	0.97	2.65	0.96	0.10	0.92
Movement exercises	3.13	0.79	2.78	0.87	2.03	0.04*
Creation of exercises related to the concrete elements learned	3.00	0.79	2.66	0.93	1.95	0.05
Lifting and falling exercises	2.54	0.99	2.34	0.95	1.13	0.26
Repetition exercises	2.96	0.84	2.50	0.98	2.39	0.02*

Note: * - $p<0.05$; 1 - separate rotations around all body axes performed in a squat with the current axis of rotation; 2 - forward rotations around the width axis of the body at different speeds around a temporarily fixed and free axis of rotation

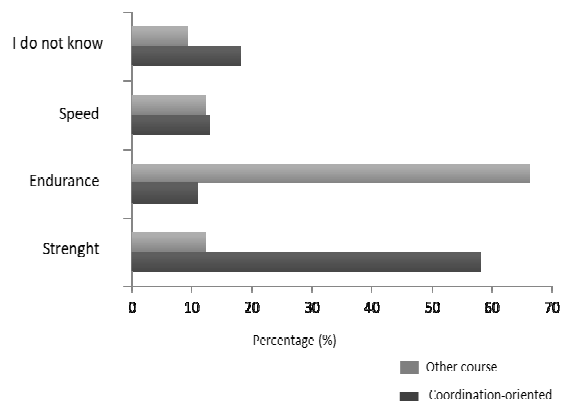
Students of both groups, the Coordination-oriented and Other course group agree that certain degrees of coordination abilities can influence the development of a self-regulated learning process ($\chi^2=4.82$; $p=0.08$). (Figure 1). Neuber et al. (2013) describe physical activity, exercise, and sport as an ambivalent field of experience in which experiences of success and failure can be directly experienced.

Figure 1 Certain degrees of coordination abilities can influence the development of a self-regulated learning process



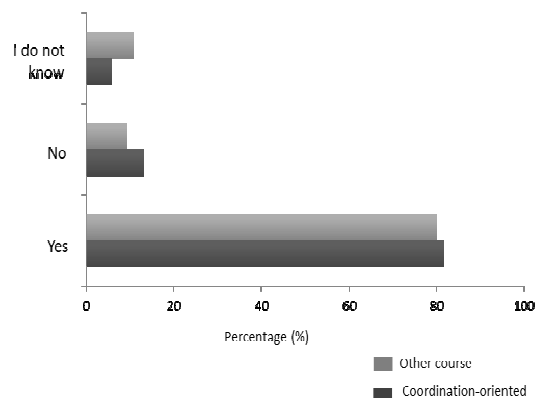
Furthermore, students estimated what kind of physical and motor activity can help them in the self-regulated learning process. The difference between the Coordination-oriented and Other course groups was significant ($\chi^2=42.87$; $p<0.001$). Most of the students in the Other course group estimated endurance (66.2%) as an activity that can help them and in the Coordination-oriented group students estimated strength (58.1%) as an activity that can help them. Spitzer (2002) describes stress-induced neuroplasticity of the brain as a way to improve a person's constitution at the cellular level. This is intended to have a positive influence on learning (Neuber et al., 2013).

Figure 2 Physical and motor activity can help students in the self-regulated learning process.



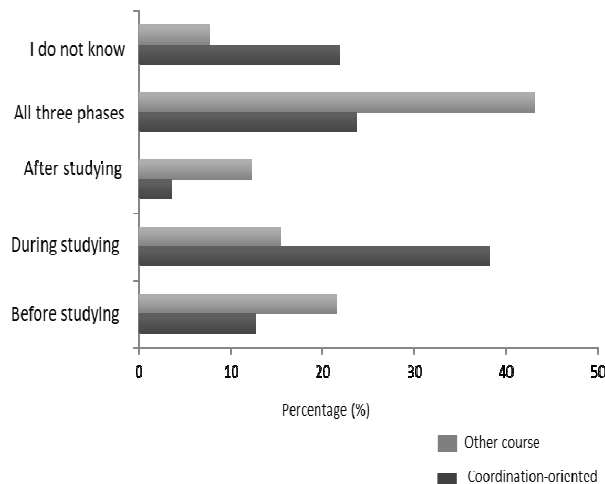
Students of both groups, the Coordination-oriented, and Other course groups, agree that the quality of coordination abilities influences the learning process ($\chi^2=1.33$; $p=0.51$) (Figure 3).

Figure 3 Quality of coordination abilities influence the learning process



Furthermore, students estimated which phase of self-regulated learning coordination ability be helpful. The difference between the Coordination-oriented and Other course groups was significant ($\chi^2=17.49$; $p<0.001$). Most of the students in the Other course group estimated all three phases as helpful (43.07%) and in the Coordination-oriented group students estimated during the studying phase as helpful (38.18%). Author Zimmerman (2000) combines the learning of skills with a high degree of self-reflection and self-regulation skills. For the author, students can learn their skills themselves if they experience a variety of planning, implementation, and design options when designing lessons.

Figure 3 In which phase of self-regulated learning can coordination ability be helpful?



Subjects answered the question: *What types of training would you like to have more intensively in practical exercises to stimulate the process of self-regulated learning?* Answers are qualitatively different concerning group, Coordination-oriented, and Other course groups: a) Out of 24 students in the Coordination-oriented group 37.5% of subjects answered strength training, 29.2% endurance training, 16.6% coordination, and 8.4% speed and aerobic training.; b) Out of 26 students in the Other course group 30.7% of subjects answered strength training, 15.4% endurance training, and 7.6% answered coordination training. Other subjects in this group highlighted some individual sports like swimming (7.6%), boxing (7.6%), running (3.8%), joga (3.8%), mountain climbing (3.8%), and fitness (3.8%). Authors argue that there is a lack of knowledge regarding the role of sport and exercise in developing and managing stress and personal health. Lutz et al. (2010) showed that high levels of stress lead to a reduction in sports activity in those people who experience exercise and sport as a stress factor and who subsequently have to force themselves to do sports. There have been many similar studies. For example, the results and research findings support the communication of success and joy as a catalyst for intrinsic motivation (Roskötter, 2013).

Discussion

The main findings of this study were to investigate students' perceptions of the relationship between the level of development of coordination abilities in physical activities and the level of development of self-regulated learning. There are several important results of this study. Research that directly links coordination skills to the development of self-regulated learning processes and academic success is rare. However, some studies investigate related aspects: a) Self-regulation of learning and academic success: Research published in the Croatian journal *Napredak* examined the components of self-regulation of learning in elementary school students. The results showed that middle elementary school students have more adaptive self-regulation of learning, which may affect their academic success (Ninčević; Jerković; Biljan, 2013). Then, research on personality traits, motivation, and learning strategies: Research on primary school students in the city of Sinj (Croatia) examined the relationship between personality traits, motivation, and learning strategies. The aim was to understand how these factors interact and influence the learning process (Reibli, 2015). The direct connection between coordination skills, the development of self-regulated learning processes, and academic success has so far been little researched. However, there is evidence of connections between physical activity, cognitive functions, and academic performance based on the following research: Coordinative abilities and cognitive processes: Current cross-sectional studies indicate that there are strong associations between children's coordination and academic performance. In particular, visual-spatial perception skills, kinesthetic differentiation, and the quality of balance regulation are seen as predictors of children's school success. One explanation for these relationships is that the execution of movements with high coordination demands also places demands on cognitive processes of information processing (Dirksen, Zentgraf, Wagner, 2015). Furthermore, also for physical activity and self-regulation: There is evidence that physical activity has positive effects on self-regulation skills. In a statement by Leopoldina, it is emphasized that physical activity is positively associated with self-regulation

and vice versa. This means that regular exercise not only promotes physical health but also strengthens the ability to self-regulate, which in turn is relevant for learning processes and academic success (Rosenkötter, 2013). This is exactly what was proven in this research. Students of both groups, the Coordination-oriented, and Other course groups, agree that the quality of coordination abilities influences the learning process ($\chi^2=1.33$; $p=0.51$) (Figure 3).

Also for the connection between sport and academic success: Theoretical and conceptual considerations suggest that a sporty, physically active lifestyle can have an indirect influence on categories relevant to academic success, especially when prevention and health promotion aspects are in the foreground. However, a direct connection to academic success cannot be established (Cho&Heran, 2015). In summary, although direct studies on the relationship between coordination skills, self-regulated learning, and academic success are lacking, existing research suggests that physical activity and good coordination skills can have positive effects on cognitive processes and self-regulation skills, which in turn support academic success. The results of the study indicate a significant relationship between the development of coordination skills and effectiveness in self-regulated learning. Students with better-developed coordination skills showed a higher level of independence in learning, planning, and monitoring their progress (Cho & Heran, 2015).

These findings suggest that physical activities that promote coordination also contribute to the development of cognitive skills necessary for self-regulation (MacDonalds, 2019). Physical activities and practical exercises that require complex movements and coordination can serve as tools for strengthening the ability to focus, set goals, and monitor one's progress (Hirtz, 2007). Research participants who participated in such activities reported a greater ability to organize their time and make independent decisions during learning (Russel et al. 2020). The application of specific teaching strategies, such as individualized approaches, progressive movement learning, and encouraging reflection, has proven to be crucial in developing coordination and self-regulation skills (Bai, 2022). Research results suggest that integrating these strategies within higher education is beneficial not only for students' physical development but also for their cognitive and academic progress. Recommendations for future practice were given by respondents to the question in the survey which referred to what types of training would like to have more intensively in practical exercises to stimulate the process of self-regulated learning. The answers differ qualitatively concerning the group of respondents, but it can be argued that the majority of respondents belonging to the coordination-oriented group believe that 37.5% would be strength training, 29.2% endurance training, and 16.6% coordination training. The findings highlight the importance of an interdisciplinary approach in education, where physical activity is not viewed solely through the prism of sport, but as a means of developing other key competencies such as self-regulation, critical thinking, and resilience. This opens up the possibility of applying these findings in other educational contexts, including primary and secondary education. Future research should include longer-term follow-ups, a larger sample of participants, and different measurement methods (quantitative and qualitative) to further confirm these findings and expand the understanding of the impact of coordination abilities on cognitive development (MacDonald, 2019). That's what this research showed; that the coordinative skills, combined with self-regulated learning, promote skills such as: a) Self-organization, b) Problem-solving skills, and d) Adaptability (Bai, 2022; MacDonalds, 2019). These skills are essential to meet the challenges of a rapidly changing world, making education more sustainable and future-oriented. This can also be cited as one of the reasons for the interest in conducting this research because the results of the conducted research indicate this.

Conclusion

While there are various scientific studies on the relationship between motor abilities and cognition, there is a lack of research regarding the influence of certain degrees of coordination abilities on the development of a self-regulated learning process. Finally, it must be noted that through exercise and sport, profound influences on the psychosocial dispositions of individuals can be realized. The research had three hypotheses: H¹ It is assumed that a certain degree of coordination abilities, motor skills, practical exercises of physical activities, and mental rotation training will influence the development of a self-regulated learning process; H² Students of coordination-oriented courses like Physical, and Health Education University will estimate the influence of the coordination abilities, motor skills, practical exercises of physical activities and mental rotation training benefits higher in the development of a self-regulated learning process, and H³ Students from two groups of courses will estimate differently the helpfulness of self-regulated learning phases on coordination abilities.

The mentioned hypotheses are all accepted given that the paper tried to point out some of the teaching strategies used in physical activities and practical exercises as part of regular higher education classes, which can encourage independent learning of movement and thus develop parallel degrees of coordination ability. The research indicated possible differences and correlations among students about dependent and independent variables. Students in the coordination-oriented group have a significantly higher maximum number of push-ups ($Z=2.89$; $p<0.001$) and back rolls ($Z=2.09$; $p=0.04$) than students in the other subject group. The students also had to evaluate how successfully they performed the practical exercises and physical activities. Differences between the coordination-focused group and the Other subject group were found in strength ($Z=2.42$; $p=0.02$). Students in the coordination-focused group rate their strength higher. Differences between the subject groups

Coordination and Other were determined in two activities - movement exercises ($Z=2.03$; $p=0.04$) and repetition exercises ($Z=2.39$; $p=0.02$). The difference between the Coordination-oriented and Other course groups was significant ($\chi^2=42.87$; $p<0.001$). Most of the students in the Other course group estimated endurance (66.2%) as an activity that can help them, and in the Coordination-oriented group, students estimated strength (58.1%) as an activity that can help them. The difference between Coordination-oriented and Other course groups was significant ($\chi^2=17.49$; $p<0.001$). Most of the students in the Other course group estimated all three phases as helpful (43.07%) and in the Coordination-oriented group students estimated during the studying phase as helpful (38.18%). Given that the research tried to answer the question of what types of training they would like to have more intensively in practical exercises to stimulate the process of self-regulated learning; the most common answers were qualitatively different concerning the group, the group focused on coordination, and the subject group Other.

The quality of the realization depends on the personal dispositions of the individuals and results from an interdisciplinary construct. So, one can conclude that a positive approach to the subject matter should enable students to experience long-term joy in doing exercise and sports. By constantly doing exercise and sport, students can learn key skills that will make them more successful in key areas of life. Thus, such research helps in understanding how the integration of physical and mental aspects can improve the broader picture of learning, training, and rehabilitation. The main objectives of this study were to examine students' perceptions of the relationship between the level of development of coordination skills, physical activities, and self-regulated learning.

The paper emphasizes the importance of physical activity teaching strategies and practical exercises within regular higher education classes, which can encourage independent movement learning. This enables the development of coordination skills while simultaneously improving self-regulated learning skills. Based on the research findings, possible recommendations for future work could include the following:

- a) expanding the sample: Include students of different ages and educational levels to explore the association across a broader population;
- b) longer-term follow-up: Conduct longitudinal studies to assess the effects of physical activity teaching strategies on coordination and self-regulated learning over a longer period of time,
- c) applying different teaching strategies: Examine the effectiveness of different teaching methods, such as gamification, individualized approaches, or group activities, in developing self-regulation and coordination skills,
- d) technology integration: Analyze the impact of using digital tools (such as motion tracking apps or video analysis) in the process of teaching physical activity,
- e) qualitative research: Conduct in-depth analyses using interviews and focus groups to better understand individual student perceptions and needs;
- f) linkages to psychological factors: Explore how motivation, self-confidence, and emotional states influence the learning process and the development of coordination skills, and
- g) interdisciplinary approach: Involve experts from different fields (e.g. psychology, kinesiology, education) to gain a broader insight into the complex connection between physical activity, coordination and learning,
- h) practical guidelines for teachers: Develop specific guidelines and manuals for teachers to effectively implement strategies that support self-regulated learning through physical activity. This was one of the reasons for the interest in this research topic.

The results obtained will be valuable to methodologists in sports and education, kinesiologists, pedagogues, and psychologists working in higher education institutions and those specializing in teaching.

Conflicts of interest

The authors declare no conflicts of interest.

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