POSSIBLE METHOD OF MEASURING COORDINATION SKILLS ON A SAMPLE OF HUNGARIAN ELITE ATHLETES

Abstract of PhD Thesis

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1. Introduction

The levels of condition and coordination skills play a decisive role in the process of acquiring and performing individual sports movements and in achieving a high level of performance. The lives of athletes are accompanied from the beginning by performance, the well-measurable determinants of which are strength, speed and endurance, the development of which can be tracked in an objective way and thus the trainings can be adjusted accordingly. In addition, the coordination of individual movements and complex elements are very important factors, which means the polishing of the accuracy of each movement, the reduction of unnecessary excess movements, the optimal energy investment and the efficiency of the movements. Developing and maintaining coordination skills as much as possible during the teaching and learning of sports movement is a primary requirement. The maximum development of these skills affects the correct technical execution and thus the athletic performance. In elite sports, the efficiency, accuracy and speed of movement learning, as well as the improvement of technical errors, fundamentally determine the pace of development as well as the performance in sports. In addition to sports professional's aspects, it plays a very important role in the development of a proper lifestyle, as well as in the development of individual muscles, organs and also in the elimination of excessive use of organ systems (Adorjánné et al. 2012).

1.1. Justification for the choice of topic

Over the years in my career as an athlete, teacher and coach, my experience has increasingly reinforced my belief that in addition to conditional skills, coordination skills, which are less prominent in sports training, play an indisputable role in terms of movement instruction and athletic performance. Over the years, the question has arisen in me as to what role of general and specific coordination skills can play in athletic performance and how the level of these complex skills could be measured in a simple way, regardless of sports. The aim of our research is to test a series of coordination tasks, with which coaches and physical educators can get directly quantifiable information about the general coordination skills of their athletes and students. In the training process of athletes, the basis of warm-up, skill development and learned

movements is indisputably provided by gymnastics. As a result of the often changing exercises, the athlete learns about the features, possibilities and limitations of his body, increasingly experiences the diverse, individual repertoire of movements of the limbs and torso, their assignment, the importance of spatial, temporal and dynamic components, while consciously and increasingly linking them into more complex movements (Adorjánné et al. 2012). Based on these thoughts, it was formulated in us to try to test the athlete's coordination level through simple gymnastic exercises. We hope that the test tasks we use can become suitable for testing and estimating the level of coordination of athletes of different levels working in different sports.

1.2. Literature review

Outstanding sports performance as well as the training and performance of athletes are influenced by several factors. For peak performance in different sports, athletes need their physical, emotional, and cognitive abilities in different proportions, depending on the type of the sport. It is the task of the coach and coaching staff to develop the abilities to the maximum, to bring the athlete's performance to the highest level. For this reason, the work of world-class athletes and teams is often supported by a well-established professional staff, where the coach, psychologist, dietitian, masseur, physiotherapist and fitness coach all work for a common goal, so that the athletes can prepare under the most perfect conditions, they can use the most up-to-date methods and thus their performance can be raised to the highest possible level. To achieve peak performance, all segments of the abilities must be developed because a combination of these ability components will determine athletic performance. In this huge set of abilities, there is a tiny slice of coordination abilities, which perhaps have the most white spots in their development and measurement.

The performance of athletes is determined by a huge number of external and internal factors. One of the important performance-determining components is the group of motor skills, which is basically divided into two major groups by the professionals; these are the conditional and coordination skills. Conditional abilities are defined as the group of physical abilities that appear as a criterion of athletic performance, which include primarily strength, speed, and endurance (Nádori 1986). Conditional abilities are closely related to each other and to coordination abilities, by which they create the

preconditions for locomotor actions (Harsányi 2000). A prerequisite for the success of the action is the development of proper synchronization in the cooperation of coordination and conditional skills (Dubecz 2009).

The other large capability group that plays a key role in performance is the coordination ability group. All professionals agree that coordination is a complicated and complex ability. In Hepp's opinion, one of the indicators of movement skills is that the athlete learns new movements quickly and easily, consciously masters his movements and movement skills and can choose the most effective solution which suits the goal best (Hepp 1973). Nádori says the same in a slightly more nuanced way. In his opinion, an athlete who can perform the movement more accurately with sufficient effort, solving two identical tasks is more adept. The skillful athlete quickly learns the unknown, new movements, and is able to quickly and effectively improve and polish the movements, which he has learned (Nádori 1986). This is a very important moment when athletes learn new sports techniques and correct technical errors. Dexterity cannot be quantified easily, it cannot be expressed in seconds, centimeters, so it is almost impossible to describe the specific degree of motor coordination with a single quantified data. The degree of dexterity can be characterized by the complexity of the task in coordination, the accuracy of execution, the duration of movement learning, and the minimum time that elapses from the stimulus to the onset of the response movement when performing an unknown movement task (Koltai and Nádori 1983). Movement learning summarizes the process of developing dexterity, proficiency, skills together with the facilitating and inhibiting factors of the process leading to automation. Mobility and agility are two closely related concepts. Mobility is a purposeful and conscious human activity that contributes to skillful actions, to the development of successful behavior. Movement skills are an expression of the quality and effectiveness of the activity (Istvánfi 2006). The diversity and economy of the basic coordination experience determines how quickly the athlete can learn and "relearn" the new coordination patterns. However, the development of motor coordination is significantly influenced by memory, the ability to evoke movement experiences based on older movement experiences, and continuous comparison with information stored in long-term memory (Jones 1987).

The current level of coordination is influenced by several external and internal factors. External factors include the part of the day, temperature, quality of the ground, clothing, sports equipment, and opponent. Internal influencing factors include age, gender, individual physical parameters, capabilities related to the innate movement, current condition and mental state. The performance of an athlete is controlled by a complex system, in which an emotional factor can influence the performance of the competitor in a positive or negative direction. World-class results and performances are created by the functional unit of physical and mental conditions (Szécsényiné et al. 2007). Farmosi and Arday (1995) examined coordination abilities and concluded that motor learning should be given a prominent role, which effectiveness strongly depends on previous experiences, similarities or differences in the kinematic, spatial, rhythmic characteristics of newly learned and previously learned movements. In terms of age, childhood and prepubertal age are considered essential for the development of general exercise skills. Nervous system maturation also plays an influential role in the development of coordination skills. However, early sexual maturation is accompanied by earlier coordination maturation and development (Hirtz 1985). In their study, Torres-Oviedo et al. (2011) concluded that speed and efficiency of motor learning are mostly important for elite athletes. In their view, the optimal age for motor learning is around 6–10 years, when the development of the motor cortex allows for very effective learning. However, they state that motor learning is an ongoing task in most sports. In his study Fényes (2009) compared the academic achievement of men and women. Based on her research results, she found that girls are in the majority in grammar schools and universities, and their performance in high school is also better. In her opinion, high school training was "invented for girls," where girls are more diligent, more successful, and more productive than boys. Girls have more self-discipline and diligence, which also helps them achieve better results (Duckworth and Seligman 2006). Czeizel (1985) shares this view, arguing that women's intellectual abilities are not worse than men's, in fact, their school performance is better.

The role of coordination abilities in sports performance is at least as important as the conditional abilities, however, measurement procedures cannot be summarized in such a system of completeness as in the case of condition abilities (Nádori et al. 1989). The assessment and measurement of basic movement skills can be solved by relatively

simple methods (Cools et al. 2009), but the assessment of complex motor skills is a particularly complex and difficult task. There are several possibilities to study conditional abilities. Studies on strength, endurance, speed, but even flexibility, joint mobility are very abundant, but information on coordination abilities is much more modest. The reason for the lack of widely used measurement methods is not the marginal effect of the coordination component of sports performance, but due to the complexity and sport specificity of the coordination ability (Hands et al. 2015). Needless to say, that the highest level of sports performance requires an exceptionally high level of motor coordination. Even moderate levels of athletic performance are impossible to achieve with poor motor coordination (Williams et al. 2016). Among the methods applied for measuring motor coordination, various static and dynamic equilibrium tasks, rhythm tasks, manipulation tasks and obstacle courses are the most common and most accepted. The exact exploration of the suitable methods for the measurement of complex motor coordination and the precise elaboration of the measuring parameters are further research tasks. It is not enough to mention the importance of coordination skills in addition to conditional skills, as the two skills are jointly responsible for the high level of performance achieved in sport. Even with outstanding physical abilities, it is not possible to provide outstanding performance without the appropriate level of coordination knowledge, so the adequate organization of movements, economical and efficient execution. The reverse is also true, so with a high level of coordination skills, even in the absence of sufficient physical skills, an athlete will not be able to provide the best of his or her technical knowledge. Within coordination skills, there is a need to develop both general and sport-specific movements, which together contribute to a high level of performance and effectiveness in sport. Based on the information so far, we can say that the high level of motor coordination is important and shows significant specialty at different sports. Although there are procedures for measuring sport-specific coordination skills or the components of the coordination capacity, they are not unified. In contrast, a generally accepted method for measuring overall coordination that can be used in several sports has not yet been developed. However, the necessity is evident from the side of both measurement and development, and also on the basis of the presented literature, what has already

been explained, that the level of coordination ability can also have a significant influence on sports performance.

2. Objectives

2.1. Purpose of the study

The aim of our study is to compile test tasks with which we hope to be able to estimate the general coordination abilities regardless of the sports and thus obtain information about the level of coordination of each athlete. For the surveys, we aimed to use equipment-free and manual tasks, which are simple and known to everyone, but untrained in such a connection. We also questioned whether there is a correlation between performance in the coordination test tasks we measured and athletic performance. We would also like to examine whether there may be influencing factors that have a positive or negative effect on the results of the coordination test tasks we measured.

2.2. Hypotheses

1. The scoring and evaluation of the exercises can be implemented uniformly after simple information, thus ensuring the easy usability of the exercises.
2. The coordination test tasks we compile show a correlation with athletic performance. An athlete who performs better in his or her own sport scores higher on the coordination test tasks.
3. Gender and age do not affect the results of the coordination test tasks. We find no difference between women and men in terms of results achieved in test tasks. During the test tasks, the older age group does not perform better than the younger age group.
4. The number of training hours per week as well as the academic results shows a correlation with the results of the coordination test tasks. Athletes, who train for several hours weekly, as well as those with better academic results, perform better in the coordination test tasks.

3. Methods

The review of the literature also reveals that there is no measurement method accepted and used by everyone, with which the level of coordination skills can be measured and examined in an exact way. We consider it necessary to develop a measuring procedure and technique, with which the level and quality of coordination skills can be estimated in a simple way, regardless of the sports. Based on my decades of experience as an athlete, coach, and teacher, I thought that gymnastics is a movement type that could be suitable for this.

3.1. Subjects

In the studies, we wanted to assess male and female athletes from different sports, competing in the higher and lower classes, as national and non-national, "more successful" and "less successful" competitors. We thought that surveying athletes in as many different sports and level as possible could prove the usability of the tests we compiled. An important consideration in the selection of sports was to select sports that require complex coordination skills, as well as to include representatives of sports with technical, tactical, and conditional ability dominance (Rigler 1996). As a technical sport, we chose rhythmic gymnastics and aerobics, as both sports specifically require a very high level and sophisticated coordination ability of the competitors. We chose handball and water polo as tactical sports, because the Hungarian women's and men's teams have internationally recognized and successful athletes in these sports. Among the sports that dominated conditional ability, we chose kayaking, which is also justified by the international success of the women's and men's disciplines. Non-athletes were also examined as a control group. The non-athlete control group was provided by students from different faculties and grades at the Budapest University of Technology and Economics. The only consideration in their selection was that they could not engage in regular sports activities either in their childhood or since.

A total of 222 athletes (n = 75 men, 147 women) were measured and compared. In the control group, 23 non-athletes (n = 9 men, 14 women) were examined. Thus, the total number of study groups was 245 (n = 84 men, 161 women). It is worth mentioning that in the practical surveys we managed to assess a total of 28 people, who was ranked

from first to third place in the Olympic, World Championships or European Championships.

3.2. Survey process

Coordination abilities are extremely difficult to measure due to their complexity, so for the survey we tried to compile exercises that would presumably provide information on general dexterity, the level of motor coordination, and the speed and accuracy of movement learning. Before the practical test tasks, the participants filled out a questionnaire, from which we collected data related to their physical (height, weight, age) and sports habits (number of training hours per week, sports age) as well as information related to their sports activities (best sports results, national team membership). We compiled a series of exercises consisting of equipment-free and one ball tasks, which included 4-4 increasingly difficult exercises built on each other. We obtained a permit for the research from the Research Ethics Committee of the University of Physical Education (TE-KEB / No7 / 2019). The sample tasks could be viewed on video by the subjects up to three times before each test task. This was followed by a maximum of 1 minute of individual practice and memorization, followed by video recording (Sony DCR-SR32E, Japan) of the movements they performed twice in each case. Subjects were identified not by name but by number. After the surveys, the practices were scored by a scoring system, in which both of their experiments were evaluated.

3.2.1. Description of the Freestyle Gymnastic Exercises (FSGE)

The basic task of freestyle gymnastic exercise is the so-called “jumping-jack” task. For FSGE, they had to perform a total of 4x4 beats at 58 bpm determined by a metronome. In the case of the first freestyle gymnastic exercise variation, the initial position of the arm was changed to a lateral middle position compared to the basic exercise, however, during the arm movement the arm assumed the same positions as the basic task and the leg movement remained unchanged compared to the basic exercise. In the second variation, we changed the leg movement compared to the basic task. They had to perform double jumps in both the spreading position and the angular position, while the movement of the arm remained unchanged compared to the basic task. In the

third variation, the arm and the leg movement variation described above were combined, with which we obtained a completely new free practice task compared to the basic task.

The execution of the tasks was evaluated on a scale ranging from 0 to 12 points and if the first attempt resulted in a perfect execution, an additional 3 points could be obtained. In the case of performing a 1x4 beat, we scored 1 point if only the arm or leg movement could be performed correctly at an inappropriate rhythm. We scored 2 points for whom both arm and leg movement were correct but rhythm was not yet, and we scored 3 points if both arm and leg movements were performed correctly and also did at the right rhythm. For multiple-pace executions, the same trend was repeated in terms of scoring.

3.2.2. Description of Coordination Ball Dribbling Exercise (CBDE)

In the case of ball dribbling exercise, they had to perform ball dribbling with two basketballs of the same size and pressure, in changed rhythms continuously, for a maximum of 30 seconds. Everyone could complete the task in the rhythm he or she developed, but they had to keep that rhythm throughout the execution. It was a mistake to drop the ball or leave the 2x2 meter area we designated. In the first ball variation, one ball was exchanged for a tennis ball and they had to perform the same movement under the conditions described in the basic task. Participants were free to choose which hand to use tennis ball or basketball with. In the second difficulty level, we changed the movement of the tennis ball. The tennis ball had to be thrown and caught all the time, while the basketball had to make ball dribbling invariably. In the last ball variation, the movement of the basketball remained unchanged and meanwhile a balloon had to be held in the air by beating. In this test task, keeping the rhythm was a condition only with basketball.

The performance of the coordination ball dribbling exercises was evaluated on a scale of 0-12 points, similar to the freestyle gymnastic exercise and in case of perfect execution for the first attempt, an extra 3 points could be obtained here as well. He received zero points for not being able to complete the task at least for 3 seconds. We scored 1 point for execution between 3-5 seconds at a non-defined rhythm and received 2 points for being able to perform at a steady rhythm over the same time period. As the

duration of implementation increased, the scores that could be obtained increased to 12 points.

3.3. Statistical analysis

In our study, almost all of the test variables surveyed are variables with discrete distributions, such as rankings or scoring of coordination test results, we use nonparametric tests to determine significant differences between groups. The Mann-Whitney U test was used to compare two groups, while the Kruskal-Wallis ANOVA test was used to determine differences between several groups. Spearman rank correlation was used to determine the correlations between these studied parameters. During the study, the significance level was defined to $p < 0.05$.

4. Results

4.1. Evaluation of the objectivity of the scoring system

Before evaluating and comparing the results, we wanted to prove the proper applicability, comprehensibility and objective use of our scoring system, so we asked three acknowledged and recognized professionals from different scoring sports to evaluate the performance of five randomly selected people from the total sample with me, according to our scoring system. To examine the correlations between the measurements of each evaluator, we performed a Bland-Altman analysis, which is suitable for evaluating the agreement between the measurements of the two evaluators. In the case of comparisons of 80 pairs of points, 2.5–11.25% of the points fell only out of the 95% limit of agreement (mean ± 1.96 SD). Based on this, it can be say that even in the components of the total scores of the individual exercises, there is no significant difference between the scores given by the different evaluator, as more than 90% of the scores are usually within the clinical limits of the two interchangeable measurements. As there was no significant difference between the different evaluators based on the trial scoring, according to the scoring system we developed, I performed the scoring of the video recordings myself in terms of freestyle gymnastic exercises and coordination ball dribbling exercises as well.

4.2. Examination of physical and age parameters

The evaluation of the results obtained in the surveys was started by comparing the physical and age parameters, which were done for both the athlete and non-athlete group and in the five different sports. A comparison of the athlete and non-athlete samples revealed that the athlete and non-athlete groups did not differ in terms of height, body weight, and age at the time of the survey, so the overall study sample was homogeneous in terms of these parameters.

We also compared physical and age parameters for 222 surveyed athletes from the five sports. Rhythmic gymnasts and aerobics players are well below regarding to both height and weight parameters compared to handball players, water polo players and kayakers. The same can be said for the age at the time of the survey, as the RG and aerobics athletes in our survey were much younger than the representatives of the other three sports. It should be mentioned that this difference is a sport feature, as in both sports the classification of the different age groups at the competitions (junior, adult) is set to a younger age than in the other three sports. Because our study group is divided into two well-distinguishable subgroups based on both physical (height, body weight) and age parameters, we treat the two subgroups separately in our further studies and comparisons so that these differences may not affect our results.

4.3. Evaluation of coordination test results

Evaluation of the results obtained in the coordination test was performed for both the athlete and non-athlete sample and in the five sports. Based on the total scores of all four freestyle gymnastic exercises and four coordination ball dribbling exercises, as well as the total results of the eight test tasks, the athletes scored significantly higher. Based on this information, we thought that the method we developed could be a good indicator for estimating the level of coordination. If it had not been any difference between the two groups, it might not have been worthwhile to investigate further with this method, as it was expected that the athlete group would achieve better results in the coordination test tasks.

When comparing the athlete sample, in freestyle gymnastic exercise, RG and aerobics competitors performed significantly better than competitors in handball, water polo, and kayak. Based on the results obtained in the freestyle gymnastic exercise test

tasks, the two subgroups are well separated in the same pattern as in the physical and age parameters. In the case of coordination ball dribbling exercise, the separation of the two subgroups is not observed.

4.4. Examination of sports performance

To examine the performance in the sport, we considered the best result of the athletes in their own sport so far. When the study sample was compiled, we paid special attention to the fact that the sports performance in each sport should be as wide as possible.

4.4.1. Setting up a performance ranking

To verify our hypothesis that athletic performance was related to scores on the coordination tests, we needed to establish a performance ranking. This presented us with a very difficult task, as we had to rank the results of athletes from different sports, with different genders, and ages, as well as the performance and the level of knowledge. We developed 20 performance categories regardless of sports, in which we considered the type and level of different sports competitions (Olympics, world competitions, continental competitions, national championships). Within each category, competitors in different sports were ranked separately and given continuous rankings based on their best results according to the number of items in the category. Within the category, the type of each competition and the achieved ranking were decisive in the ranking by sport. For those who had the same result, we also considered their further results. Where we could not differentiate on this basis either, the competitors who achieved exactly the same result all received the same rank.

Based on the performance rankings we have allocated, kayaking and water polo are the most successful sports among the five sports surveyed. It is known that in Hungary, athletes achieve outstanding results in the sports of kayaking and water polo, while the success of the other three sports lags far behind. Thus, bearing in mind that our sample is not representative of Hungarian elite athletes, the averages of our survey groups well reflect the distribution of the performance of our Hungarian athletes in these five sports.

4.5. Relationship between coordination test results and athletic performance

We hypothesized that athletes with a higher level of coordination are more successful in their own sport, so we compared the subjects' overall scores on the four freestyle gymnastic exercise test tasks with the performance rank they obtained. The relationship between the two variables is illustrated in Figure 1.

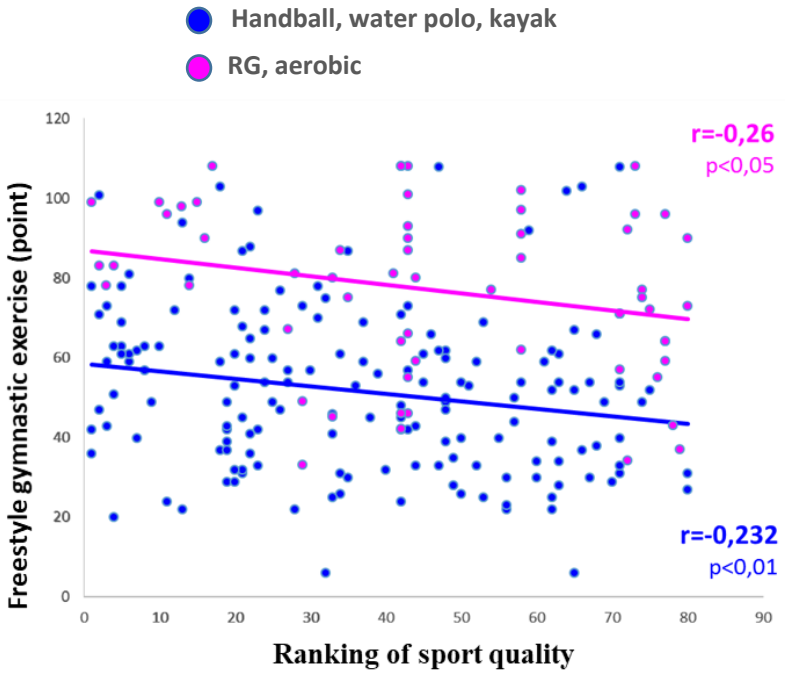

Fig. 1.
Relationship between the results achieved in freestyle gymnastic exercise and sports performance

Scores in freestyle gymnastic exercise and performance ranking show a correlation in both subgroups. Competitors who were more successful in their own sport scored higher in the freestyle gymnastic exercise test tasks.

We also compared the results achieved in the coordination ball dribbling exercise tasks and the sports performance ranking. In this case, the data show a significant variance and the results in the performance ranking and CBDE tasks did not show any correlation in either study subgroup (handball, water polo, kayak subgroup $r = 0.086$ $p>0.05$; RG, aerobics subgroup $r = 0.082$ $p>0.05$), so we do not deal with the further evaluation of the measurement method based on coordination ball dribbling exercise.

4.6. Examination of influencing factors

After finding a correlation between athletic performance and coordination test tasks, we further investigated whether there are any factors that may underlie the correlation we found and could lead to erroneous conclusions. Thus, we examined whether gender, age, number of training hours per week, and study outcome could have an influencing effect on results achieved in coordination test tasks.

Gender differences were examined only in sports where both were represented. We do not found any significant difference in athletic performance between women and men in our study. Based on these, we can say that the female and male competitors surveyed in the study did not differ in their highest athletic results, so the possible numerical disproportion of the sexes in the surveyed sample could not affect the correlation.

The next possible influencing factor was the effect of age on our results. For both study subgroups, there was a correlation between survey age and performance ranking. The performance provided in the freestyle gymnastic exercise we used in the case of the handball, water polo, and kayak subgroup with an average age of over 22 did not show a correlation with the age at the time of the survey. However, in the case of RG, an aerobic subgroup with a much younger average age, under 18, we found a correlation in the study of the same parameters.

In our research we found it interesting that in the five sports the competitors indicated the training time on a very wide scale (6-45 hours / week), so we considered it important to examine the possible effect of the number of training hours per week on our results. In the handball, water polo, kayak subgroup, results showed the free practice test tasks and the sports performance also correlate with the number of training hours per week. In the RG, aerobic subgroup, no correlation was found when examining the same parameters.

In examining the influencing factors, we questioned whether mental abilities may have an influencing effect on our coordination test results. The estimation of mental abilities was based on the average result of the baccalaureate certificate, and in the case of subjects who did not have a baccalaureate certificate due to their age, we evaluated the average result of the last certificate. In this comparison, we could not show a correlation when examining the two subgroups separately, but when examining the

whole sample, we could show that the athletes with better academic results performed better in the coordination test tasks, so they scored higher.

5. Conclusions

The level of sports performance is determined by a complex set of abilities, of which a sub-component is coordination, the degree of it manifests differently in every sports, such as in rhythmic gymnastics or kayaking, but this does not mean that coordination skills in the highest level as possible would not be important in both sports for reaching better performance. Without measuring the level of an ability and knowing the factors influencing development, it is difficult to create a training plan that is based on scientific knowledge. If the test we developed can be used to assess different levels of overall coordination, then considering this, our study can be a useful tool for improving athletic performance.

Our first hypothesis, according to which the scoring and evaluation of the exercises can be implemented uniformly after simple information, has been confirmed, as the evaluation of the five randomly selected competitors by four judges show a high degree of similarity, thus ensuring similar evaluation and usability of the exercises.

Our second hypothesis, according to which the coordination test tasks we compiled show a correlation with sports performance, was confirmed in terms of freestyle gymnastic exercise, while in the case of coordination ball dribbling exercise we did not find a correlation. Since our hypothesis regarding the freestyle gymnastic exercise test tasks was fulfilled, we assume that this set of tasks can be used to assess the development of the general level of coordination in the preparation of the competitors. It is questionable whether sports performance correlates with results on a freestyle gymnastic exercise test, then including similar exercise tasks in training could contribute to raising the performance of different sports to a higher level and thus athletic performance. Demonstration of this hypothesis projects further researches in this field.

Our third hypothesis regarding gender comparison was confirmed. To the best of our knowledge, although there are significant differences between men and women in

terms of conditional abilities (strength, speed, endurance), this existing difference did not affect their performance in performing the applied coordination test tasks. The age claim of the hypothesis that the older age group does not perform better than the younger age group has been partially substantiated. Older subjects did not perform better in the 18+ age group, however in the age group under 18, older subjects did better in our coordination task. In this age group, biological maturation plays a decisive role, as the development is on a rapid scale from year to year, which is also reflected in our results. Based on these, we can state that the results of tasks we tested are not influenced by gender and in the group over the age of 18 are not influenced by age eider, so it can be applied regardless of gender and age in adults.

Our statement regarding the number of weekly training hours in our fourth hypothesis was partially confirmed. Regarding handball, water polo, kayak subgroup, athletes performing sports activities in the higher number of weekly training hours performed better in the test tasks used in our survey. In fact, this is an encouraging observation that well reflects the importance of practical training for the development of coordination. In the RG, aerobics subgroup, we found no correlation between the number of training hours per week and their performance in the test tasks. We saw the reason for this in the extremely high number of training hours, which probably no longer has further developmental effect on coordination skills. The statement of the hypothesis regarding academic results was partially confirmed. Examining the two subgroups separately, we could not show a correlation, however, in the case of the whole study sample, the academic achievements and the scores obtained in the coordination test showed a positive correlation. However, this result may be indicated due to several background influencing factors. On one hand, the better performance of the RG, aerobics subgroup in freestyle gymnastic exercise tasks certainly stems from the similarity between the test tasks and their own sports exercises. On the other hand their better academic results are probably due to their young age, even in the absence of a baccalaureate certificate, we could only use the average of the most recent certificate. Thus, the relationship we obtained should be evaluated in the light of these influencing factors, which does not exclude a possible relationship between mental abilities and coordination abilities, but more serious, study of broader spectrum is needed to examine this relationship.

Our results suggest that those who show excellent results in the freestyle gymnastic exercise test tasks have good coordination base to become a successful athlete. It would be worthwhile to further investigate whether the freestyle gymnastic exercise tasks we employ could potentially be used to select children in different sports as well as to recognize talent. Our long-term plans include varying other sets of gymnastic tasks similar to the freestyle gymnastic exercise test tasks according to the same system and applying these variable practice sets in the process of foundation movement training and preparation for different sports, as well as examining long-term impact on improving overall coordination. In addition, we would like to design special sport training tasks that start from the specific forms of movement of different sports, like the variation system used in our studies, resulting different sets of tasks with different levels of difficulty. We would like to test the usefulness and effectiveness of the application of these practical tasks, with which, in our opinion, we could contribute to the development of general and special coordination skills to reach higher level of sports performance and effectiveness.

6. List of own publications

List of own publications related to the topic

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Hamar P, Adorjánné OA, Kalmár Zs, Karsai I. (2011) 11-18 éves magyar és erdélyi tanulók érzelmi reakciói az iskolai testnevelés iránt. Kalokagathia, 49(2-4): 225-238.

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