Author(s): Jaakkola, Timo; Watt, Anthony; Kalaja, Sami

Title: Differences in the Motor Coordination Abilities Among Adolescent Gymnasts, Swimmers, and Ice Hockey Players

Year: 2017

Version:

Please cite the original version:

Jaakkola, T., Watt, A., & Kalaja, S. (2017). Differences in the Motor Coordination Abilities Among Adolescent Gymnasts, Swimmers, and Ice Hockey Players. Human Movement, 18(1), 44-49. https://doi.org/10.1515/humo-2017-0006

HUMAN MOVEMENT
2017; 18 (1): 44–49

DIFFERENCES IN THE MOTOR COORDINATION ABILITIES AMONG ADOLESCENT GYMNASTS, SWIMMERS, AND ICE HOCKEY PLAYERS

original paper
doi: 10.1515/humo-2017-0006

TIMO JAAKKOLA[1], ANTHONY WATT[2], SAMI KALAJA[3]

[1] Department of Sport Sciences, University of Jyväskylä, Jyväskylä, Finland
[2] College of Arts & Education, Victoria University, Melbourne, Australia
[3] KIHU Research Institute for Olympic Sports, Jyväskylä, Finland

ABSTRACT
Purpose. Motor coordination is proposed to be a relatively stable age-related construct, unlikely to be influenced by aligned experiential factors such as intensive sport-specific training. The purpose of the study is to investigate if there are differences in motor coordination abilities among young artistic gymnasts, swimmers, and ice hockey players.
Methods. The participants of the study were 508 female and 258 male adolescents (age, M = 12.80, SD = 1.10) comprising artistic gymnasts (n = 463), swimmers (n = 70), and ice hockey players (n = 233). The KTK-test protocol was used to analyse their gross motor coordination abilities.
Results. The results of the study demonstrated that gymnasts scored better than ice hockey players and swimmers in the test of walking backwards along a beam, and better than ice hockey players in total motor coordination, hopping over an obstacle, and the test of moving sideways on wooden boards. However, ice hockey players scored higher than swimmers and gymnasts in the test of jumping from side to side. Subsequently, swimmers obtained better results in the test of moving sideways on wooden boards as compared with ice hockey players.
Conclusions. The study results indicate that intensive sport-specific training may extend young athletes' motor coordination characteristics in the ability areas representative of the sport in which they engage.
Key words: motor coordination, youth, sports, motor development, ability, KTK-test

Introduction

There is an increasing trend within the sports sciences to investigate the motor coordination attributes of children and adolescents [1]. This is because motor coordination has been shown to be a strong predictor of athletic success in childhood and adolescence [2–6]. Motor coordination has been described as a relatively stable general physical construct that includes various aspects of motor ability [6, 7]. In this study, motor coordination is delineated by the characteristics measured within the KTK-test protocol (Körperkoordinationstest für Kinder) [8, 9]. The motor performances representative of motor coordination in this study include walking backwards on a balance beam, moving sideways, hopping over an obstacle, and side-to-side jumping.

Previous evidence has supported the stability of motor coordination in childhood. For example, Vandorpe et al. [6] in their longitudinal study recognized that children between 6 and 9 years of age demonstrated stable patterns in relation to motor coordination. Their findings revealed that even active participation in sports club activities for over 3 years did not have a contributing effect on the development of motor coordination. Similar findings were reported by Ahnert et al. [10], who demonstrated that stability coefficients in motor coordination exceeded 0.70 for over 2 years in elementary school, suggesting high stability. However, there is also contrasting evidence showing that motor coordination may not be a stable construct because active participation in sport-specific programs was found to be related to specific development of motor coordination. In particular, Rudd et al. [11] observed that a 10-week gymnastic program in physical education developed 8–12-year-old children's motor coordination as assessed by the KTK-test. Additionally, Montezuma et al. [12] found that 13–18-year-old adolescents with a hearing loss improved their motor coordination during a sport-spe-

Correspondence address: Timo Jaakkola, Department of Sport Sciences, University of Jyväskylä, Rautpohjankatu 8, P.O. Box 35 (Viv), 40014 University of Jyväskylä, Finland, e-mail: timo.jaakkola@jyu.fi

Received: February 13, 2017
Acepted for publication: March 21, 2017

Citation: Jaakkola T, Watt A, Kalaja S. Differences in the motor coordination abilities among adolescent gymnasts, swimmers, and ice hockey players. Hum Mov. 2017;18(1):44–49; doi: 10.1515/humo-2017-0006.

cific intervention involving 12 dance classes. To conclude, on the basis of previous research findings, it is not yet clear whether motor coordination is influenced by environmental factors such as intensive sport practice.

One possibility to investigate if intensive sport-specific training is associated with the development of motor coordination is to analyse if there are differences in motor coordination skills between children and adolescents who intensively train and participate in different type of sports. However, to our knowledge, there is only one study so far investigating if there are differences in motor coordination skills of children and adolescents engaging in different sports. Opstoel et al. [13] reported that 9–11-year-old children who participated in martial arts had significantly lower motor coordination when compared with those practising dance, ball games, gymnastics, racquet sports, and swimming. However, significant differences were only identified in the moving sideways test of the KTK-test battery [8, 9].

This study adds knowledge to the field of research of motor coordination by continuing to evaluate if motor coordination is stable or modifiable owing to the influence of environmental factors. More specifically, the current study was designed to extend the findings of Opstoel et al. [13], also by investigating whether children and adolescents who intensively engage in different sports demonstrate variation in motor coordination skills as measured by the KTK-test battery. The research includes two important age- and sport-related contributions. Firstly, in the study by Opstoel et al. [13], the athletes were 9–11 years old, whereas the current study involved older athletes (i.e. 11–14 years old). We may therefore argue that the athletes in our sample have more experience of intensive practice, and longer training histories may have an effect on the development of motor coordination. Secondly, in the current study we also recruited a group of ice hockey players who have trained intensively on ice for years. This type of training environment is likely to be effective in improving dynamic balance, an important source of motor skill performance data collected by the KTK-test battery. The purpose of the study is to investigate if there are differences in motor coordination skills measured by the KTK-test protocol among young artistic gymnasts, swimmers, and ice hockey players, who all have relatively intensive training backgrounds in their sports. On the basis of the results of the previous study [13], we hypothesize that motor coordination skills vary among athletes involved in different sports.

Material and methods

Participants and procedure

The participants of the study were 766 junior athletes aged 11–14 years ($M = 12.80$, $SD = 1.10$). The sample comprised 508 girls and 258 boys who were classified as gymnasts ($n = 463$), swimmers ($n = 70$), or ice hockey players ($n = 233$). All the athletes in the sample are active in competitive sport and have an intensive training history in their sports. The 11–12-year-old studied athletes have 5–6 sport-specific trainings every week, whereas the 13–14-year-olds have 7–9 sport-specific training sessions every week. The average duration of one training session was approximately 90 minutes in each sport. All the athletes trained and competed only in one sport. The competitive level was national in all the cases. The swimmers belonged to the 'Rollo' training group, which is a group for talented swimmers organized by the Finnish Swimming Association. The gymnasts were so called 'Minori-athletes' from the Finnish Gymnastic Federation. They are elite representatives of regional gymnastic clubs. The ice hockey players took part in the 'Mini Pohjola' try out-camps. They were selected through the Finnish Ice Hockey Association's regional talent identification system in Southern Finland.

The participants completed the KTK-test package during their typical training sessions in a quiet gym. All the tests were conducted by experienced measurement administrators. The participants were informed

Table 1. Description of the KTK-test battery subtests

Subtest	Test description
Walking backwards along three beams of decreasing width	The child walks backwards on three balance beams of decreasing width (6, 4.5, 3 cm). All beam walks are performed three times.
Hopping over obstacles of increasing height	The child hops on one leg over a foam cuboid obstacle. After a successful performance with each leg, the instructor adds one piece of foam on the pile. Each piece of foam is 5 cm thick and the maximum number of foams in the pile is 12.
Moving sideways on wooden boards (20 s)	The test involves movements incorporating two boards (25 × 25 × 2 cm) and is conducted over a 20-second interval during which the child stands on one board and keeps their hands on another one, moves the first board alongside the second one, and steps on it.
Two-legged jumping from side to side (15 s)	The child completes 15 seconds of consecutive jumping movements from one side to another with their legs in the parallel position. The jumps are performed over a small wooden beam (60 × 4 × 2 cm).

that the test results would be used to develop the quality of the training program in their sports and to study motor coordination within young Finnish athletes. They were also provided information that their involvement in the study was voluntary and that their data would be kept anonymous.

Instrument

The KTK-test protocol [8, 9] was adopted analyse the participants' gross motor coordination. The KTK package includes four tests: 1) walking backwards along three beams of decreasing width, 2) hopping over obstacles of increasing height, 3) moving sideways on wooden boards (20 s), and 4) two-legged jumping from side to side (15 s). Descriptions of all the KTK subtests are presented in Table 1. A more detailed reference to the organization of the KTK-test is included in the test manual [8, 9].

The raw scores of each subtest and the total score were converted into standardized motor quotient (MQ) scores, which represent gender- and age-controlled values. Converting raw scores into MQ scores was based on the procedure described in the KTK-test manual. Most previous studies using the KTK-test battery applied MQ scores instead of raw scores in the data analyses [1].

The KTK-test protocol has been developed to investigate 5–15-year-old children's and adolescents' motor coordination. The test has been used to analyse motor coordination within groups of special needs children [14–16] and non-special needs children [13, 17, 18]. The KTK-test protocol has proved to be a reliable tool to assess children's motor coordination with test-retest correlations for different subtests reported from 0.80 to 0.96 [8, 9].

Statistical analysis

Means, standard deviations, and Pearson correlation coefficients were determined to investigate patterns of association among the variables. One-way analyses of variance (ANOVA) with Tukey post hoc tests were used to determine differences in motor coordination skills between the groups. Additionally, eta-squared was calculated to report the effect sizes for the ANOVAs (0.02 = small, 0.13 = medium, 0.26 = large) [19]. In all the analyses, the level of significance was set at 0.05. IBM SPSS Statistics for Windows, version 22 (2013 SPSS Inc.; IBM Corp.; Armonk, NY, USA) was applied for the statistical analyses.

Results

The descriptive statistics and Pearson correlation coefficients are presented in Table 2. The descriptive statistics demonstrate that the participants' MQ scores were higher for the subtest of two-legged jumping from side to side and moving sideways on wooden boards, and lower in hopping over obstacles of increasing height and walking backwards along beams of decreasing width. The Pearson results indicate that the MQ total presented a moderate-to-strong correlation with all the four subtests. However, the associations among the subtests were small.

Table 3. Results of the analyses of variance (ANOVA) of the scores for the subtests and total score of the KTK protocol measure

Variable	Gymnastics			Swimmers			Ice hockey players			*F*-value	*df*	*p*-value	Eta-square
	n	*M*	SD	*n*	*M*	*SD*	*n*	*M*	*SD*				
MQ, total	462	124.22	9.16	47	124.64	8.90	221	121.73	10.10	5.57	2; 727	0.004	0.015
MQ, walking backwards	462	112.21	8.85	70	108.68	10.43	229	108.62	11.85	11.66	2; 758	< 0.001	0.030
MQ, hopping over obstacles	461	111.26	9.10	47	110.75	6.09	226	109.45	6.06	3.78	2; 731	0.023	0.010
MQ, jumping side to side	462	122.77	11.61	69	122.16	14.41	229	132.07	11.25	50.82	2; 757	< 0.001	0.118
MQ, moving on wooden boards	462	129.45	13.06	69	132.19	11.48	233	118.40	16.87	53.28	2; 761	< 0.001	0.123

Table 2. Descriptive statistics and correlation coefficients among the study variables

	n	*M*	*SD*	1	2	3	4
1. MQ, total	730	123.49	9.49	–			
2. MQ, walking backwards	761	110.81	10.13	0.60**	–		
3. MQ, hopping over obstacles	734	110.67	8.14	0.54**	0.23**	–	
4. MQ, jumping side to side	760	125.52	12.53	0.59**	0.14**	0.17**	–
5. MQ, moving on wooden boards	764	126.33	15.15	0.74**	0.29**	0.20**	0.13*

MQ – motor quotient, * $p < 0.05$, ** $p < 0.001$

The analysis of variance (ANOVA) of the scores for the subtests and the total score of the KTK protocol measure revealed a range of significant differences (Table 3). Total MQ scores were significantly different among the groups, with Tukey post hoc results indicating that gymnasts scored higher in the total MQ than ice hockey players ($p = 0.004$). The scores for the test of walking backwards along beams revealed significant differences between group means, with Tukey post hoc results proving that gymnasts scored higher in the test compared with swimmers ($p = 0.016$) and ice hockey players ($p < 0.001$). The group scores for the subtest of hopping over obstacles of increasing height were significantly different, with Tukey post hoc results showing that gymnasts scored higher than ice hockey players ($p = 0.017$). For the subtest of two-legged side-to-side jumping, significant group differences were found, with Tukey post hoc results demonstrating that ice hockey players scored higher than swimmers ($p < 0.001$) and gymnasts ($p < 0.001$). Finally, the group scores for the subtest of moving sideways on wooden boards depicted significant differences, with Tukey post hoc results revealing that gymnasts and swimmers scored higher in the test compared with ice hockey players (both $p < 0.001$).

Discussion

The results of the study demonstrated that gymnasts generally performed better than swimmers or ice hockey players in the test protocols. Specifically, gymnasts scored higher than ice hockey players and swimmers in the test of walking backwards along a beam, and higher than ice hockey players in total motor coordination (total MQ), the hopping over obstacles test, and the test of moving sideways on wooden boards. However, ice hockey players scored better than both swimmers and gymnasts in the test of jumping from side to side. Subsequently, swimmers obtained higher results in the test of moving sideways on wooden boards as compared with ice hockey players. Overall, the results of the investigation extend the limited information currently available in relation to differences in the motor coordination skills of younger athletes practising sports with various motor skill and physical requirements.

The motor learning literature has typically detailed that motor coordination is a relatively stable and age-related construct [5, 6]. However, previous studies in the area have produced contradictory results as to whether motor coordination can be improved as an outcome of intensive sport-related practice [6, 10–12, 20]. The results of this study provide evidence highlighting that motor coordination skills assessed across adolescence demonstrate greater variability than previously reported [5, 6]. One reason for the discrepancy is the different age of the participants, which was higher in the current study. Older children are more likely to have greater experience of intensive practice in their sports. Longer training histories in particular sports have supported the variation in the development of motor coordination skills as relevant to the demands of each sports discipline.

It is also notable that the study has identified a greater variety of differences in the motor coordination skills of young athletes engaged in different sports than the previous similar research [13]. The study by Opstoel et al. [13] included athletes practising numerous sports; however, the subgroups were much smaller than those in the current study, which may have limited the capacity to find significant group differences. It is also possible that the comparison of our results with those obtained by Opstoel et al. suggests that the sports included are clearly distinct from each other relative to motor coordination requirements.

In our study, the differences in motor coordination identified between the participants in gymnastics, swimming, and ice hockey could be aligned with a logical association to the intensive and specific training history representative of the different sports. For example, gymnasts performed better than other athletes in walking on a beam task, which could be attributed to their substantial training and competition experience in balancing activities. Training experience may also be the reason why ice hockey players performed better in the two-legged jumping test. Skating involves push-offs which are similar to the take-offs in the two-legged jumping test. Although the test take-offs are implemented with both legs parallel, these two tasks are still biomechanically very close to each other. For example, take-off directions and demands for dynamic balance do not differ between these two performances. The study also revealed that gymnasts had higher scores in comparison with ice hockey players in total MQ score and three subtests of the KTK package, representative of agility, dynamic balance, and hopping. We also consider these results plausible because the training environment in gymnastics is much closer to the subtests of the KTK than the training and competition environment of ice hockey. Gymnasts are typically used to performing different jumps and controlling their bodies while using different apparatus. It can be suggested that gymnastics generally scored better in the individual KTK-tests than ice hockey players as their training environment is much closer to most motor performances measured by the KTK-test. Swimmers, in turn, achieved the highest mean MQ total in the KTK scores of the three sports groups. Although the major portion of swimmers' training is held in the water, they also have out-of-pool sessions where they do 'dry practices' which include jumps, coordination, and gymnastics. This may have limited the differences due to motor coordination training influences between swimmers and gymnasts.

It should be acknowledged that the presented study could not identify specific reasons to explain the differences found in motor coordination skills; therefore, the findings should be considered cautiously. It may also be possible that young athletes, for example, start and continue their sports practice because their motor coordination 'matches' the demands of a particular discipline. If children recognize that they perform well in a given sport at an early age, they may engage more enthusiastically to develop their competence towards that sporting activity and commit themselves to the training and competition demands of the activity [21].

The results of this study encourage practitioners to develop training programs which help equally acquire all aspects of motor coordination. The research demonstrated that participating in ice hockey, swimming, and artistic gymnastics improved specific aspects of motor coordination. However, there is a versatility in motor coordination experiences during childhood and adolescence that has been shown to be a strong predictor of later athletic success [2–6]. Therefore, it is important that youth training programs include practice involving a variety of motor coordination characteristics.

An interesting finding was that subtests of the KTK-test battery had only small intercorrelations, varying from 0.13 to 0.29. For example, Kiphard and Schilling [8] in their original data demonstrated intercorrelations varying between 0.60 and 0.81. A reason why the correlations were higher in the original data might be that they also included younger children [8, 9]. According to motor learning literature, motor abilities appear clearer in younger age groups [5]. Older children begin to engage in intensive sport-specific activities whereby the focus is on specific motor coordination skills that are further influenced by mixed inherited motor abilities and environmental learning effects. This is probably why associations among the results of the KTK-test package subtests were not high in our data. However, the total MQ score correlated much stronger, with the four subtest coefficients varying from 0.54 to 0.74. The associations between the total MQ score and the four subtest scores support the validity of applying motor coordination sum-score in the data. However, small intercorrelations among the four subtests suggest the independence of the motor skill tasks and reinforce the importance of considering the scores of the four subtests separately.

Limitations of this study include the cross-sectional design, which does not allow to draw interpretations on the cause-effect relationships. Additionally, group sizes were uneven in the study. The group of gymnasts was much larger than the sample of swimmers. Additionally, it should be recognized that the whole sample, as well as the subsamples included uneven distribution of boys and girls. Subsequently, a weakness of the study was an inaccurate overview of the athletes' training history. In future research, the focus should be on longitudinal and intervention studies to determine whether motor coordination is a stable construct or one influenced by sport-oriented practice undertaken during childhood and adolescence. These studies should also include athlete samples from a variety of sports disciplines to allow further understanding of how different sporting experiences affect the development of motor coordination. Future studies should also include gender and age analyses.

Conclusions

The results of the study demonstrated that gymnasts generally performed better than swimmers or ice hockey players in the test protocols. The differences in motor coordination identified among the participants in gymnastics, swimming, and ice hockey could be aligned with a logical association to the intensive and specific training history representative of the different sports. It may also be possible that young athletes, for example, start and continue their sports practice because their motor coordination abilities 'match" the demands of a particular discipline. If children recognize that they perform well in a given sport at an early age, they may engage more enthusiastically to develop their competence towards that sporting activity and commit themselves to the training and competition demands of the activity.

References

1. Iivonen S, Sääkslahti A, Laukkanen A. A review of studies using the Körperkoordinationstest für Kinder (KTK). Eur J Adapt Phys Activ. 2015;8(2):18–36.
2. Vandorpe B, Vandendriessche J, Vaeyens R, Pion J, Lefevre J, Philippaerts R, et al. The value of a non-sport-specific motor test battery in predicting performance in young female gymnasts. J Sports Sci. 2012;30,5:497–505; doi: 10.1080/02640414.2012.654399.
3. Pion J, Fransen J, Deprez D, Segers V, Vaeyens R, Philippaerts R, et al. Stature and jumping height are required in female volleyball, but motor coordination is a key factor for future elite success. J Strength Cond Res. 2015;29(6): 1480–1485; doi: 10.1519/JSC.0000000000000778.
4. Callewaert M, Boone J, Celie B, De Clercq D, Bourgois J. Indicators of sailing performance in youth dinghy sailing. Eur J Sport Sci. 2015;15(3):213–219, doi: 10.1080/17461391.2014.905984.
5. Magill RA. Motor learning and control: concepts and applications, 8th ed. New York: McGraw-Hill; 2007.
6. Vandorpe B, Vandendriessche J, Vaeyens R, Pion J, Matthys S, Lefevre J, et al. Relationship between sports participation and the level of motor coordination in childhood: a longitudinal approach. J Sci Med Sport. 2012;15(3): 220–225; doi: 10.1016/j.jsams.2011.09.006.
7. Lopes L, Santos R, Pereira B, Lopes V. Associations between gross motor coordination and academic achievement in elementary school children. Hum Mov Sci. 2013;32(1): 9–20; doi: 10.1016/j.humov.2012.05.005.
8. Kiphard EJ, Schilling F. Körperkoordinationstest für Kinder. Weinham: Beltz Test; 1974.
9. Kiphard EJ, Schilling F. Körperkoordinationstest für Kinder 2, überarbeitete und ergänzte Aufgabe. Weinham: Beltz Test; 2007.
10. Ahnert J, Schneider W, Bös K. Developmental changes and individual stability of motor abilities from the preschool period to young adulthood. In: Schneider W., Bullock M. (eds.). Human development from early childhood to early

adulthood: Evidence from the Munich longitudinal study on the genesis of individual competencies (LOGIC). Mahwah: Erlbaum; 2009; 35–62.
11. Rudd J, Farrow D, Barnett L, Berry J, Borkoles E, Polman R. A pilot study to evaluate the efficacy of the 'Launchpad' gymnastics programme at developing children's motor coordination and fundamental movement skills. J Sci Med Sport. 2014;18,Suppl.1:e11; doi: 10.1016/j.jsams.2014.11.034.
12. Montezuma M, Rocha M, Busto R, Fujisawa D. Hearing impaired adolescents: dance learning and motor coordination. Rev Bras Educ Esp. 2011;17(2):321–334; doi: 10.1590/S1413-65382011000200010.
13. Opstoel K, Pion J, Elferink-Gemser M, Hartman E, Willemse B, Philippaerts R, et al. Anthropometric characteristics, physical fitness and motor coordination of 9 to 11 year old children participating in a wide range of sports. PLoS One. 2015;10(5):e0126282; doi: 10.1371/journal.pone.0126282.
14. Gheysen F., Loots G., van Waelvelde H., Motor development of deaf children with and without cochlear implants. J Deaf Stud Deaf Educ. 2008;13(2):215–224; doi: 10.1093/deafed/enm053.
15. Hanewinkel-van Kleef YB, Helders PJM, Takken T, Engelbert RH. Motor performance in children with generalized hypermobility: the influence of muscle strength and exercise capacity. Pediatr Phys Ther. 2009;21(2):194–200; doi: 10.1097/PEP.0b013e3181a3ac5f.
16. Van Aken K, Caeyenberghs K, Smits-Engelsman B, Swillen A. The motor profile of primary school-age children with a 22q11.2 deletion syndrome (22q11.2DS) and an age- and IQ-matched control group. Child Neuropsychol. 2009; 15(6):532–542, doi: 10.1080/09297040902740678.
17. Freitas D, Lausen B, Maia J, Lefevre J, Gouveia É, Thomis M, et al. Skeletal maturation, fundamental motor skills and motor coordination in children 7–10 years. J Sports Sci. 2015;33(9):924–934; doi: 10.1080/02640414.2014.977935.
18. Olesen LG, Kristensen PL, Ried-Larsen M, Grøntved A, Froberg K. Physical activity and motor skills in children attending 43 preschools: a cross-sectional study. BMC Pediatr. 2014;14(1):229; doi: 10.1186/1471-2431-14-229.
19. Pierce CA, Block RA, Aguinis H. Cautionary note on reporting eta-squared values from multifactor ANOVA designs. Educ Psychol Meas. 2004;64(6):916–924; doi: 10.1177/0013164404264848.
20. Vandendriessche J, Vaeyens R, Vandorpe B, Lenoir M, Lefevre J, Philippaerts RM. Biological maturation, morphology, fitness, and motor coordination as part of a selection strategy in the search for international youth soccer players (age 15–16 years). J Sports Sci. 2012;30(15): 1695–1703; doi: 10.1080/02640414.2011.652654.
21. Stodden D, Goodway J, Langendorfer S, Roberton M, Rudisill M, Garcia C, et al. A developmental perspective on the role of motor skill competence in physical activity: an emergent relationship. Quest. 2008;60(2):290–306; doi: 10.1080/00336297.2008.10483582.