

Physical Fitness Measures Among Adolescents With High and Low Motor Competence

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Pórdís Gísladóttir¹, Monika Haga²,
and Hermundur Sigmundsson^{2,3}

Abstract

Physical fitness level is considered to yield substantial health benefits. Earlier studies have demonstrated poor physical fitness outcomes and reduced level of physical activity among adolescents. There have been very few studies on adolescents concerning motor competence and its possible relationship with physical fitness. This study's aim was to compare physical fitness in adolescents aged 15 to 16 years with high (HMC) and low motor competence (LMC). From an initial sample of 94 adolescents, a group of 18 were identified as having HMC or LMC on the Movement Assessment Battery for Children-2. Eight adolescents (3 girls and 5 boys) comprised the LMC group, and 10 children (5 girls and 5 boys) made up the HMC group. To measure physical fitness, four tasks were used: one endurance test, one power test, one speed test (Test of Physical Fitness) and one flexibility test (EUROFIT). A one-way ANOVA revealed significant differences between the group with LMC and the HMC group in all tasks except the endurance task (Reduced Cooper Test). The findings suggest that physical fitness components are negatively associated with LMC. However, no significant difference between the two groups in the Reduced Cooper Test might indicate that adolescents with LMC can enhance their cardiovascular fitness despite their poor motor coordination.

Keywords

adolescents, high motor competence, low motor competence and physical fitness

Introduction

Physical fitness refers to a set of inherent or achieved personal attributes that relate to the capacity to perform physical activity and/or exercise (Caspersen, Powell, & Christenson, 1985; Ortega, Ruiz, Castillo, & Sjöström, 2008). Research conducted in the last decade has provided evidence that physical fitness is an important marker of health in children and adolescents (Ortega et al., 2008; Sardinha, Froberg, Riddoch, Page, & Anderssen, 2008). Effects and health outcomes of health-related fitness has indicated a link to cardiovascular disease risk factors (Anderssen et al., 2007), overweight and obesity (Ortega et al., 2011), and skeletal health (Fonseca, de França, & Van Praagh, 2008).

Despite the known benefits of physical activity and fitness, physical activity levels tend to decrease with age (Trost et al., 2002), and time spent in sedentary behavior increases, especially during adolescence (Pate, Mitchell, Byun, & Dowda, 2011). A scientific documentation of a decline in adolescents physical fitness level is limited (Malina, 2007). However, the prevalence of overweight and obesity (Neumark-Sztainer, Wall, Eisenberg, Story, & Hannan, 2006) relative to the time spent in sedative activities (Pate et al.,

2011) can indirectly be a sign of such a trend in this age group. Therefore, identifying possible determinants that are associated with physical fitness and activity levels in adolescents may help to develop specific prevention strategies and promote a healthy lifestyle.

An individual's ability to perform compound motor tasks has been considered to be a possible determinant of physical fitness (Barnett, Beurden, Morgan, Brooks, & Beard, 2008; Haga, 2009; Kantomaa et al., 2011) and physical activity level (Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006). An individual's ability to master different fundamental movement skills and sport specific motor skills may offer a greater motor repertoire to participate in various physical activities, sports, and games, and as a consequence lead to an increased

¹Reykjavík University, Iceland

²Sør-Trøndelag University College, Trondheim, Norway

³Norwegian University of Science and Technology, Trondheim, Norway

Corresponding Author:

Hermundur Sigmundsson, Department of Psychology, Norwegian University of Science and Technology, Dragvoll, 7491 Trondheim, Norway.

Email: hermundurs@svt.ntnu.no

fitness level (Barnett et al., 2008). However, little is known about the relationship between motor competence and physical fitness throughout the life span in general (Stodden, Langendorfer, & Roberton, 2009), and in adolescence in particular.

Some children and adolescents experience considerable difficulties with coordinating and controlling their body movements. The current, dominant term to describe this condition is developmental coordination disorder (DCD; Kirby, Edwards, & Sugden, 2011). DCD is a complex disorder characterized by poor motor skills that has adverse effects on activities of daily living, leisure activities, sports, and academic achievement (American Psychiatric Association [APA], 2000); the prevalence ranges between 1.8% (Lingam, Hunt, Golding, Jongmans, & Emond, 2009) and 6% (APA, 2000). The etiology of DCD is unclear (Magalhães, Missiuna, & Wong, 2006). The long-term prognosis is variable; a small proportion tends to improve but more often adolescence and adulthood are characterized by persisting motor difficulties (Cantell, Smyth, & Ahonen, 2003). In children, low motor competence (LMC) is associated with decreased participation in physical activity (Bouffard, Watkinson, Thompson, Dunn, & Romanow, 1996; Cairney, Hay, Faught, Corna, & Flouris, 2006) and below-average performance on different components of physical fitness including overweight and obesity, cardiorespiratory fitness, flexibility, and muscle strength (Cantell, Crawford, & Doyle-Baker, 2008; Haga, 2008a, 2009). Moreover, longitudinal studies examining the changes in components of physical fitness over time confirm how the negative effects of LMC persist as children grow older (Haga, 2009). In addition, children with motor problems and low preference for active play tend to be at high risk of physical inactivity and low cardiorespiratory fitness in adolescence (Kantomaa et al., 2011). As it is unlikely that children with motor problems will grow out of their coordination difficulties (Cantell et al., 2003), it is probable that other negative consequences of the condition will persist into adolescence and adulthood (Cairney, Hay, Faught, & Hawes, 2005). A concern might therefore be whether adolescents with LMC experience lowered physical fitness outcomes with a subsequent elevated risk of adult disease. Physical activity habits established in adolescence are likely to extend into adulthood (Conroy, Cook, Manson, Burning, & Lee, 2005). Consequently, promoting physical fitness through engagement in physical activity in early life is essential for the prevention of negative health outcomes during the life course (Ortega et al., 2008).

Regarding adolescents, there have been few studies concerning motor competence and its association with physical fitness (Cantell et al., 2008; Stodden et al., 2009).

Stodden et al. (2009) found a strong association between motor skill competence and physical fitness in young adults (18-25 years). Motor skill competence was assessed by maximum kicking and throwing speed and maximum jumping

distance, and fitness was measured by a 12-min run/walk, curl-ups, grip strength, maximum leg press strength, and percentage body fat. In total, motor skill competence predicted 79% of the variance in overall fitness (Stodden et al., 2009). A significant association between motor competence and physical fitness was also found in adolescents (mean age 14.1 years) with high (HMC) and low motor competence, respectively, favoring the high competence group for all fitness measures (Hands, Larkin, Parker, Straker, & Perry, 2009). Physical fitness was measured by chest pass, curl-ups, sit and reach, shoulder stretch, body composition and cardiovascular endurance (bicycle ergometer), and motor competence was assessed by the McCarron Assessment of Neuromuscular Development (MAND). On the contrary, Cantell et al. (2008) found no significant difference between adolescents (17-18 years old) with HMC or LMC using different fitness measures (pulmonary function/vital lung capacity and forced vital capacity, flexibility, muscular endurance, and strength).

It is clear from the literature that there is need for more studies focusing on the relationship between motor competence and physical fitness in adolescents. We have not been able to find any studies that focus on these factors in the age group 15 to 16 years. Thus, this paper is set out to compare physical fitness in adolescents aged 15 to 16 years with HMC and LMC.

Method

Participants

One hundred and one adolescents aged 15 to 16 years were assessed on the Movement Assessment Battery for Children-2 (MABC-2; Henderson, Sugden, & Barnett, 2007) and four tasks measuring components of physical fitness. A total of 94 adolescents completed all test items, 46 girls and 48 boys. The entire sample was ascertained from two secondary schools in Reykjavik, Iceland. The sample included adolescents in a wide range of socioeconomic backgrounds and reflected the population of this age group in the city. The mean chronological age of the sample was 15.9 years ($SD = 0.25$), the overall range being 15.7 years to 16.4 years old. The mean age for the girls was 15.8 years ($SD = 0.24$) and for the boys 15.9 years ($SD = 0.26$).

From the initial sample ($n = 94$), the students were divided into two groups on the basis of their MABC-2 total score. According to the MABC-2 test, poor performance is represented by low standard and percentile scores. Eight adolescents scored below the 5th percentile in this study with a standard score of 5 or lower and were classified in the LMC group. The 10 adolescent with the highest score were allocated to the HMC. These adolescents had a standard score of 13 or higher, placing them above the 84th percentile. The mean chronological age were 15.9 ($SD = 0.29$) years for the LMC group and 15.9 ($SD = 0.24$) years for the HMC group.

Table 1. Gender, Chronological Age, and Scores on the MABC-2 for Participant With Low Motor Competence and High Motor Competence.

Low motor competence group			High motor competence group		
Participant	Age (years)	MABC-2	Participant	Age (years)	MABC-2
		Standard score			Standard score
1 (M)	15.9	4	9 (F)	15.8	14
2 (M)	15.8	4	10 (F)	16.2	14
3 (F)	15.8	4	11 (M)	15.9	14
4 (M)	16.4	5	12 (M)	16.3	13
5 (M)	16.4	5	13 (M)	15.10	13
6 (M)	15.10	5	14 (M)	15.9	13
7 (F)	15.8	5	15 (F)	15.7	13
8 (F)	15.9	5	16 (F)	15.8	13
			17 (F)	16.2	13
			18 (M)	15.11	13
Mean	15.9	4.6		15.9	13.3
SD	0.29	0.52		0.24	0.48

Note. M = male; F = female; MABC = Movement Assessment Battery for Children-2.

The LMC group consisted of five boys and three girls, and the HMC consisted of five boys and five girls. The mean MABC-2 scores for the LMC and HMC groups were 4.6 ($SD = 0.52$) and 13.3 ($SD = 0.48$), respectively (see Table 1).

The MABC-2

The MABC-2 is an improved version of the MABC (Henderson et al., 2007). It provides a global test of motor competence, with assessment of fine and gross motor coordination and is designed for the age group from 3 to 16 years. The MABC-2 comprises a quantitative (a standardized test) and a qualitative (Checklist) evaluation of a child's motor competence in daily life. The test component contains eight subtests that are divided into three categories: (a) manual dexterity (three subtests), (b) ball skills (two subtests), and (c) static and dynamic balance (three subtests). Raw scores on items are summed and converted to a percentile rank. The test battery employs different tasks for children of different ages. A child's performance is referenced to a standardized sample value of children of the same age. The score is represented in three zones: red zone, amber zone, and green zone. A score in the green zone represents normal motor performance (>15th percentile). Adolescents with the total test score above 67 (standard score 8) are classified in the green zone and as having normal motor performance. A score in the amber zone is considered borderline performance (between the 5th and 15th percentile). Adolescents with total score between 57 and 67 (standard score 6-7) are considered in the amber zone and might be at risk of having a movement difficulty. Adolescents with the total test score up to and including 56 (standard score 1-5) score in the red zone and are classified as having a motor problem (<5th percentile)

relative to children and adolescents of the same age. The MABC-2 has good reliability, with a minimum test-retest at any age of 0.77 and interrater reliability of 0.79 (Henderson et al., 2007). The MABC has also been validated against other measures of motor performance. Validity has been established with 80% agreement between the MABC and Bruininks-Oseresky Test of Motor Performance (Crawford, Wilson, & Dewey, 2001).

Testing of Physical Fitness

To measure physical fitness, four tasks were used: Three of the tasks (strength, speed and endurance; test items 1, 2, and 3) were selected from the Test of Physical Fitness (TPF; Fjørtoft, Pedersen, Sigmundsson, & Vereijken, 2011). One flexibility test (test item 4) was selected from the EUROFIT (Adam, Klissouras, Ravazzolo, Renson, & Tuxworth, 1998).

The four test items are as follows:

1. *Standing broad jump.* The participant starts with the feet parallel and a shoulder width apart behind a starting line. At a signal, the participant swings his or her arms backward and forward and jumps with both feet simultaneously as far forward as possible. The test item score (the better of two attempts) is the distance (in centimeters) between the starting line and the landing position.
2. *Running 20 m as quickly as possible.* The participant starts in a standing position. At signal the participant runs as fast as possible toward the finish line. The test item score is the time in seconds needed to run the 20 m.

Table 2. Mean (SD) Score for Each of the Four Tasks and Total Score (Average z-Score) of Fitness Tasks for the Two Groups.

Physical fitness test	Low motor competence		High motor competence			
	N	M (SD)	N	M (SD)	p value ^a	PES
Standing broad jump (cm)	8	136.75 (39.33)	10	194.70 (43.59)	.005	.374
Running 20 m (s)	8	3.99 (0.31)	10	3.69 (0.20)	.019	.283
Sit and reach (cm)	8	19.88 (6.37)	10	29.95 (10.29)	.018	.287
Reduced cooper test	8	1,098.75 (145.13)	10	1,128.3 (113.33)	NS	.015
Total test score (z-score)	8	-2.18 (2.05)	10	1.27 (1.92)	.002	.456

Note. PES = partial eta squared; NS = not significant.

^aANOVA one-way $p < .05$.

3. *Reduced Cooper Test.* The participant runs or walks around a marked rectangle measuring 9×18 m (the size of a volleyball field) for 6 min. Running and walking are allowed. The test item score is the distance covered (in meters) in 6 min.
4. *Sit and reach test.* The participant sits on the floor with straight legs against a box and reaches as far forward along the scale on the box pushing the ruler with extended fingertips. The participant should hold the final position steady for 2 to 3 s without bouncing. The test box is 32 cm in height, and has a 45-cm-wide top plate. The length of the top plate is 75 cm, the first 25 cm of which extend over the front edge of the box toward the subjects. The soles of the subject's feet are placed against the front end of the box. The test item score is the length of the ruler pushed with the hands on the box.

The following materials are needed for administering the test items: masking tape, tape measure, stopwatch, gymnasium mats, marking cones, and measuring box for flexibility test.

Procedure

The study was carried out in accordance with the Declaration of Helsinki and ethical approval was issued by the National Bioethics Committee. Prior to gathering of data, participants and parents were given written information about the nature of the study. Written consent was obtained from the participants and parents/guardians prior to the involvement in the study. Identification numbers were used to maintain data confidentiality.

The assessment of motor competence took place in a school gym during normal school hours, and was conducted in accordance with the MABC-2 manual. All the adolescents were tested on the MABC-2 and the four fitness tasks in the time range from 9 a.m. to 11 a.m. The adolescents were tested individually by assistants who had been trained in the test protocols. Each test item was explained and demonstrated before the participant started. Each test item was

performed twice, except for the endurance running. Participants were given verbal encouragement and support throughout the testing procedure. When the participant made a procedural error, instructions and demonstrations were repeated, and the participant made a new attempt. All participants got a proper warm up directed by a physical education teacher before the test started. The adolescents had suitable physical clothing during the test.

Data Reduction and Analysis

To express the adolescent's total performance on the four physical fitness measures as one score, a total test score was calculated by using *IBM SPSS Statistics version 19.0 for Windows* (SPSS Inc., Chicago, IL, USA). Test item scores were transformed into standardized scores (z-scores) using the mean of the whole sample ($n = 94$). The z-scores were converted in this way to ensure that higher scores always indicated better performance than lower scores. Subsequently, the total test score per adolescent was calculated as the average z-score on all test items performed successfully by that adolescent. Given that the initial sample was selected randomly and that the data were approximately normally distributed, parametric statistics were used for data analyses between the groups (one-way ANOVA). Effect size was calculated using partial η^2 . The partial η^2 can be interpreted as the proportion of variance in the dependent variable (different physical fitness tasks) that is attributable to each effect (effect of groups). Statistical significance was set at $p < .05$.

Results

The mean scores (measured in seconds and meters) of the four different tasks and the total score (average z-score) of the LMC and HMC group are provided in Table 2. The mean MABC-2 total test scores (z-score) for the LMC and HMC groups were -2.18 ($SD = 2.04$) and 1.01 ($SD = 1.79$), respectively. Significant differences between the two groups were found in all tasks except the endurance task the Reduced Cooper Test. The detailed results of the analyses of variance are reported below for each test item and the total score.

Standing Broad Jump

A significant difference between the groups was found, $F(1,17) = 10.172$, $p = .005$, and the effect size was medium (partial $\eta^2 = .374$).

Running 20 Meters

A significant difference between the groups was found, $F(1,17) = 6.720$, $p = .019$, and the effect size was medium (partial $\eta^2 = .283$).

Sit and Reach

A significant difference between the groups was found, $F(1,17) = 6.850$, $p = .018$, and the effect size was medium (partial $\eta^2 = .287$).

Reduced Cooper Test

A significant difference between the groups was not found in this task, $F(1,17) = 0.261$, $p = .616$, and the effect size was small (partial $\eta^2 = .015$).

Total test score

A significant difference between the groups was found, $F(1,17) = 14.270$, $p = .002$, and the effect size was large (partial $\eta^2 = .456$).

Discussion

This study reveals that the LMC adolescent group had inferior fitness results compared with the HMC group on the total score of physical fitness, and in three out of four test items (standing broad jump, running 20 m, and sit and reach)—test items where muscular strength and flexibility are of considerable importance. No significant difference was found between the groups in the Reduced Cooper Test, a test item used to estimate aerobic fitness.

These findings are partly in line with Hands et al. (2009), reporting a significant association between motor competence and physical fitness in adolescents (14 years old) with HMC and LMC, favoring the HMC group for all fitness measures, including muscular strength, flexibility and aerobic fitness. Moreover, our findings are not concurrent with the findings of Cantell et al. (2008), reporting no significantly poorer ratings for the LMC group in fitness components in adolescent (17-18 years old). Stodden et al. (2009) also found a strong association between motor skill competence and physical fitness; however, Stodden's study researched young adults (18-25 years).

Similar findings conducted on studies of younger children demonstrate that motor competence plays an important part in physical fitness outcomes (Haga, 2008a; Hands & Larkin,

2006). Children with motor learning difficulties aged 5 to 8 years (Hands & Larkin, 2006) and 9 and 10 years (Haga, 2008b) had significantly lower performance on fitness tasks compared with the control group. A systematic review of 40 peer-reviewed studies reported varying degrees of negative associations between body composition, cardiorespiratory fitness, muscle strength and endurance, anaerobic capacity, power, physical activity, and poor motor proficiency in children and adolescents (Rivlis et al., 2011). However, it may be problematic to compare younger and older age groups as the nature of the relationship between motor competence and fitness may change in character during life span (Stodden et al., 2009). It can be concluded that younger children are more influenced by their poor underlying motor skills when performing physical activities compared with adolescents due to the nature of physical activity they engage in. On the other hand adolescents with LMC have extended opportunities to select relatively simple technical activities/task, or repetitive, steady-state fitness activities such as running, walking, and biking that places low demand on motor competence. It can be argued that adolescents, including those with a LMC, have acquired adequate technical skills for participating in physical activities at a sufficient intensity and frequency level to develop cardiovascular fitness. Therefore it is most likely that the highest physical fitness gains will occur in endurance-related activities in adolescents with LMC. Based on that, it can be suggested that endurance exercises should be promoted as an appropriate and fulfilling physical activity for this group. The findings highlight the need to focus on appropriate physical activity for this age group, because during adolescent years decisions are made as to whether to incorporate an active life style into their future physical fitness habits. Thus, adolescents with sufficient endurance levels are more likely to demonstrate higher levels of physically activity as adults (than adolescents with lower endurance levels), as well as being less likely to develop cardiovascular diseases in their adult years (Halfon, Verhoef, & Kuo, 2012).

Our findings reflect upon the changes and the type of activities different age groups are involved in. The nature of young children's play is often characterized with a higher level of physically active play compared with older children and adolescents. Active play makes a significant contribution to health-enhancing physical activity of many primary school-aged children (Brockman, Jago, & Fox, 2010). Children with HMC have better chance to master different fundamental movement skills that are used in sports and games and may find it easier to participate in physical activity, whereas children with LMC may choose a more sedentary life style because of their motor competence (Cairney et al., 2006; Hands & Larkin, 2002). A child's level of motor competence is a prerequisite for participation in physical activity, and reciprocally, participating in physical activity leads to movement experience and further development of motor competence (Hands & Larkin, 2002). In the age range

13 to 16 years, there is a change in physical activity pattern as children games diminished and there is a rapid decline of physical activity participation (Ries, Granados, & Galarraga, 2009). However, adolescences, including those with LMC, could be less influenced by their peers and parents with regard to what kind of activities they choose to participate in compared with younger children. This might lead to participation in activities that match their level of motor proficiency in a better way, and yet still develop components of physical fitness such as cardiovascular fitness. Furthermore, research, however, is needed on the relationship between motor competence and aerobic fitness in all age groups.

Limitations and Future Research

The present study had several limitations that will motivate future work. For example, the groups were not measured or matched for anthropometric differences or body composition (e.g., weight/length and body mass index). This variable might have potential impact on the performance of different aspects of physical fitness. In addition, adolescent's perceived self-efficacy in athletic competence was not assessed. This can affect the desire to participate in physical activities and physical performance, especially in children with LMC. The statistical power of the relatively small sample also must be taken into account. The sample size also prevents the possibility to analyze the difference between genders. Future research should focus on a larger sample of subjects in different age groups.

Conclusion

The findings suggest that physical fitness components are negatively associated with LMC. There is a significant difference between the LMC and HMC groups on the total score of physical fitness and the tasks involving strength, speed, and flexibility, favoring the HMC group. Interestingly, however, the results indicate that the least difference between LMC and HMC groups occurred during the endurance test. These results indicate that adolescents with LMC can enhance their cardiovascular fitness despite their poor motor coordination. Given that endurance is one of the most important factors in health-related fitness, it is imperative to develop this factor at all ages. These finding can give practical recommendations for professionals engaged within this area. From a purely skills-based viewpoint it would be logical to work on improving the weaknesses in motor competence. However, from a health-related viewpoint the goal of the professionals is to lay the foundations for long-term physical activity of the individual, which will lead to longer term health benefits. The results indicate that adolescents with LMC can engage successfully in endurance activity such as running. From a pedagogical viewpoint, the professionals should build on the strengths that exist within the

individual, and thus provide them with a foundation for their physical fitness in the future. The finding that there was no significant difference between LMC and HMC in the endurance run is important in that it might offer LMC individuals the possibility to take part in endurance-based activities on an equal basis and help them choose activity that they can succeed in. By encouraging the LMC adolescents to build on the strengths that they have might lead to positive attitudes toward physical activity and increase the possibility that they will undertake physical activity in the long term.

Declaration of Conflicting Interests

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Author Biographies

Thordis Gisladdottir is an assistant professor in sport sciences and physical education. Her research focuses on adolescents participation in sport and physical activity with a special interest in motor competence and fitness.

Monika Haga is an associate professor in physiotherapy. Her research focuses on motor development, physical fitness, physical activity and health in children and adolescents.

Hermundur Sigmundsson is a professor in biological psychology. His research focuses on learning and skill development.