

Accepted Manuscript

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PII: S1440-2440(17)30433-4
DOI: <http://dx.doi.org/doi:10.1016/j.jsams.2017.05.007>
Reference: JSAMS 1525

To appear in: *Journal of Science and Medicine in Sport*

Received date: 17-9-2016
Revised date: 14-4-2017
Accepted date: 15-5-2017

Please cite this article as: Meester An De, Stodden David, Goodway Jacqueline, True Larissa, Brian Ali, Ferkel Rick, Haerens Leen. Identifying a motor proficiency barrier for meeting physical activity guidelines in children. *Journal of Science and Medicine in Sport* <http://dx.doi.org/10.1016/j.jsams.2017.05.007>

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Identifying a motor proficiency barrier for meeting physical activity guidelines in children

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Word count: 3294 words

Abstract word count: 250 words

Number of Tables: 3

Number of Figures: 1

Word count: 3294 words

Abstract word count: 250

Number of Tables: 3

Number of Figures: 1

Abstract

Objectives: This study examined the existence of a threshold level (proficiency barrier) of actual motor competence (MC) below which a child is not likely to attain 60 minutes of moderate-to-vigorous physical activity (MVPA) per day.

Design: A cross-sectional study

Methods: Actual MC was assessed in 326 children (48.5% boys; age=9.50±1.24yrs) using the Test of Gross Motor Development-2; MVPA was measured with ActiGraph GT3X+ accelerometers. Perceived MC, included as a potential mediating variable, was assessed with the Self-Perception Profile for Children. Binary logistic (mediation) regression analyses controlling for sex and a chi-squared test were used to gain insight into the relationship between (the levels of) actual MC and the percentage of children meeting the MVPA guideline.

Results: Actual MC significantly predicted the percentage of children meeting the guideline ($B = .03$, $SE = .01$, $p < .001$), even when controlling for sex. Perceived MC did not mediate this relationship. Children with high actual MC (65-100 percentile) were 2.46 ($p=.003$) times more likely to meet the guideline than children with low actual MC (0-27 percentile).

Conclusions: The present study demonstrates the potential impact of low MC on children's MVPA levels and suggests evidence for the existence of a proficiency barrier for meeting MVPA guidelines. Almost 90% of the children whose actual MC is below the 'average' threshold do not meet the MVPA guideline. As more children with higher levels of actual MC meet the guideline than their less competent peers, it is crucial to provide opportunities to sufficiently develop children's actual MC.

Keywords: moderate-to-vigorous physical activity, health-related guideline, children, regression analysis, chi-square distribution, motor skills

Introduction

The short- and long-term benefits of moderate-to-vigorous physical activity (MVPA) for children's and adolescents' physical, mental, emotional and social health have been extensively reported^{1,2}. Yet in the last decade youth MVPA levels have decreased or stagnated in most countries and only a minority of children and adolescents meet the current worldwide recommendation of at least 60 minutes of MVPA per day³. More specifically, only 42% of 6–11 year-old American children meet the PA guidelines⁴. This is a troubling trend, particularly because more than 35% of American children in this age group are overweight or obese (age-adjusted BMI $\geq$ 85th percentile)⁵.

Various underlying mechanisms (e.g., physical self-concept, motivation, self-efficacy) contribute to the development of a physically active lifestyle^{6,7}. Motor competence (MC) is one of these mechanisms⁸⁻¹⁰ and is defined as the degree of skilled performance in a wide range of motor tasks as well as the movement quality, coordination and control underlying a particular motor outcome¹¹. Haubenstricker and Seefeldt¹² suggested there might be a threshold level of MC¹³ above which a child will be more likely to engage in various types of physical activity as they are able to successfully participate (due to adequate MC levels) in a greater variety of physical activities. Below this threshold, a child is less likely to engage in such activities¹² as he/she would not have the prerequisite skill level to be successful, and as a result, lack the

confidence and motivation to engage in physical activities. This hypothesized ‘proficiency barrier’ is suggested to emerge between the phase where children are noted to develop a broad foundation of motor skills (e.g., running, kicking, throwing) and the phase where they acquire more complex or transitional motor skills (as demonstrated in more structured games and eventually specific sports; e.g., playing soccer)¹³. This transition typically coincides with the shift from early childhood to middle childhood¹⁴. Children with MC levels below the proficiency barrier may demonstrate decreased success and enjoyment in various activities across childhood leading to subsequent higher dropout rates of sports and PA over time¹⁵. As children with low MC experience more difficulty when attempting challenging movement tasks¹³, they may be more at risk for an inactive lifestyle compared to peers with higher MC levels¹⁶. For example, Wrotniak et al.¹⁶ found that children in the highest quartile of MC (compared to the study sample) averaged 17.8 minutes/day more MVPA than children in the three lowest MC quartiles. However, it was not reported how many children in each of the MC quartiles engaged in at least 60 minutes of MVPA per day. While previous research provided evidence for the existence of a proficiency barrier among 18-25-year-old adults in relation to normative fitness levels¹⁵, the existence of a proficiency barrier among children in relation to normative MVPA levels has not yet been examined.

Children’s self-perception of their MC also is consistently related to their PA and has been noted as the strongest correlate of PA compared to other self-concept variables⁶. Two studies indicated that the positive relationship between children’s MC and their MVPA levels is mediated by the perceptions of their MC^{17,18}. However, a recent study among Kindergarten school children (*M* age = 5 years and 7 months) which examined the mediating role of perceived MC in the relationship between object control competence and physical activity did not find any support for the mediating role of perceived MC¹⁹. It remains thus unclear whether perceived MC affects MVPA levels in all children to the same extent and whether it consistently mediates the relationship between actual MC and physical activity. Therefore, the aims of this study were to examine 1) whether there is evidence for a threshold level (proficiency barrier) of actual MC, below which a child is less likely to attain 60 minutes of MVPA per day, and 2) whether perceived MC mediates the relationship between actual MC and the percentage of children meeting the MVPA guideline. It was

hypothesized that children with low levels of actual MC will be much less likely to demonstrate 60 minutes of MVPA per day¹⁶. Alternatively, children with high levels of actual MC¹⁶ were hypothesized to be more likely to meet the MVPA guideline. Furthermore, perceived MC was expected to (partially) mediate the relationship between actual motor competence and the percentage of children meeting the MVPA guideline^{9,17,18}.

Methods

A convenience sample of 361 children (180 boys; 49.86%) with a mean age of 9.49 years ($SD = 1.24$, range 6.92-11.83 years) from three different states in the U.S. participated in the current study. Children were recruited from an urban school district in Ohio, a rural school in Texas and a before-and-after school program in Michigan. The sample was predominantly non-Hispanic White (47.9%), Hispanic (25.8%) and African American (22.1%). Prior to participation, permission was obtained from the school districts and university Institutional Review Boards, as well as the schools in the three geographical locations. The parents of participating children provided consent and children provided assent. MVPA data were missing in 35 children, resulting in a final sample of 326 children (158 boys; 48.5%, M age = 9.49, $SD = 1.26$).

Actual MC was measured with the Test of Gross Motor Development - second edition (TGMD-2), a valid and reliable (test-retest reliability $r \geq .88$, inter-rater reliability $r > .98$) norm-referenced measure assessing six locomotor skills (run, gallop, hop, leap, horizontal jump, slide) and six object-control skills (striking a stationary ball, stationary dribble, kick, catch, overhand throw, and underhand roll)²¹. The TGMD-2 was administered at school by a team of trained researchers who followed the standard testing procedure, which took approximately 15 minutes per child. In line with TGMD-2 procedures, children performed two trials per skill and each skill had between three to five criteria on which skills were assessed. Intra- as well as inter-rater reliability for coding was above .90. Scores of both trials were summed to obtain a raw score for each skill, with a higher score indicated better MC. The six locomotor skill scores and the

six object-control skills were summed to provide an overall score which was then converted to a percentile score, standardized for age and sex²¹.

Children's perceptions of their MC were assessed using the sport/athletic competence subscale of the Self-Perception Profile for Children (SPPC)²². The SPPC is a highly reliable (internal consistency reliability of $0.71 \leq r \leq 0.91$ for the different subscales and $0.76 \leq r \leq 0.91$ for the sport/athletic competence subscale) and valid instrument to assess different dimensions of self-perception among children²³. Answering categories of the sport/athletic competence subscale (6 items) consist of a four-choice structured-alternative format. The child is first asked to decide with which kind of child he or she identifies most, the one(s) described in the first part of the sentence or the one(s) described in the second part of the sentence (e.g., 'Some children do very well at all kinds of sports but other children don't feel that they are very good when it comes to sports.'). Subsequently, the child decides whether the description in the part of the sentence he/she chose is "really true" or "sort of true" for him/her. Each item was accordingly scored from one (low perceived competence) to four (high perceived competence). The scores of the six items were summed and then divided by six, providing a minimum score of one and a maximum score of four²².

ActiGraph GT3X+ accelerometers (Manufacturing Technologies Inc., Shalimar, FL) were used to assess children's MVPA levels. Children were instructed to wear the accelerometer on the right hip during waking hours and to remove it only for sleeping and water-based activities (e.g., showering or swimming). Children wore accelerometers for a minimum of five days (three weekdays and two weekend days) and all the accelerometers collected data over 15 second epoch time intervals. Cutoff points for physical activity in youth as defined by Evenson et al.²⁴ (6–16 years) were used. The sum of moderate (2296–4011 counts) and vigorous (>4012 counts) PA (MVPA) were used. Acceptable inclusion criterion for wear time was at least nine hours per day²⁵. Compliance with wearing accelerometers was facilitated by guidelines previously published²⁶.

First, a binary logistic regression analysis controlling for sex was conducted to examine whether actual MC significantly predicted the percentage of children meeting the guideline of 60 minutes of MVPA per day. Subsequently, the relationship between actual MC and the percentage of children meeting the

MVPA guideline was further analyzed to detect the hypothesized proficiency barrier. Therefore, children in the present study were categorized into three actual MC groups based on the norms as described by Ulrich²¹: low (0-27 percentile), average (28-64 percentile) and high (65-100 percentile). Similar cut-off points were used in a previous study that used KTK-measurements to divide children into the same three groups²⁷. Most of the previous studies that categorized children based on their MC used cluster analyses^{20,28}. However this technique was not recommended for the present study since cluster analyses categorize children based on their competence relative to the study sample and the aim of this study was to identify a real overall proficiency barrier (not just within the study sample). After categorizing the children into three actual MC groups another binary logistic regression analysis with sex as covariate was conducted to examine the likelihood of children in each of the actual MC groups meeting the MVPA guideline. Finally, a chi-squared test was performed to examine the relationship between the actual MC groups and the percentage of children meeting the MVPA guideline.

To examine the mediating role of perceived MC in the relationship between actual MC and the percentage of children meeting the MVPA guideline a binary logistic mediation regression analysis controlling for sex was conducted. All statistical analyses were conducted in IBM SPSS Statistics 22.0. Statistical significance was set at $p < 0.05$.

Results

The means and standard deviations of the variables, as well as the correlation coefficients among these variables, are shown in Table 1. Children had a mean percentile score for actual MC of 19.15 ($SD=22.23$) and a mean perceived MC score of 3.15 ($SD=.57$; 1-4 scale). On average children engaged in 41 minutes MVPA per day ($SD=22.65$) and 16.26% of the children (53 out of 326) engaged on average in at least 60 minutes MVPA per day during the minimum of five days that they were wearing the accelerometers. For the purpose of this study, the latter group was considered to meet the MVPA guideline on a regular day.

The binary logistic mediation regression analysis indicated that, while controlling for sex ($B = 0.63$, $SE = .17$, $\text{Exp}[B] = 1.88$, $p < .001$), actual MC significantly predicted the percentage of children meeting the MVPA guideline ($B = .03$, $SE = .01$, $\text{Exp}[B] = 1.03$, $p < .001$). The grouping based on the normative actual MC data²¹ classified 76.07% of the children ($n = 248$) in the ‘low actual MC’ group, 15.64% ($n = 51$) in the ‘average actual MC’ group and only 8.28% ($n = 27$) in the ‘high actual MC’ group. The binary logistic regression analysis with the actual MC groups as predictor and sex as covariate revealed that children with average or high actual MC were respectively 1.09 ($p = .763$) and 2.46 ($p = .003$) times more likely to meet the MVPA guideline than children with low actual MC (Table 2). Boys were 1.86 ($p < .001$) times more likely to meet the guideline compared to girls. Finally, the chi-squared test revealed that only a small percentage (11.69%) of the children with low actual MC engaged in at least 60 minutes of MVPA per day (29 out of 248; 19 boys), while 25.49% of the children with average MC met the MVPA guideline (13 out of 51; 11 boys), and 40.74% of the children with high actual motor competence engaged in at least 60 minutes of MVPA per day (11 out of 27; 7 boys). An overview of the mean scores for actual MC and the percentages of children meeting the MVPA guideline per group can be found in Table 3.

The results of the binary logistic mediation regression analysis indicated that perceived MC did not mediate this relationship between actual MC and the percentage of children meeting the MVPA guideline (direct $B = .03$, $SE = .01$, $p < .001$; indirect $B = .17$, $SE = .04$, $p < .001$, Fig. 1). Actual MC was a significant predictor of perceived MC ($B = .01$, $SE = .00$, $p < .001$) but perceived MC did not significantly predict the percentage of children meeting the MVPA guideline ($B = .03$, $SE = .31$, $p = .93$).

Discussion

The results of the present study provide evidence for the existence of a proficiency barrier in terms of actual MC below which a child is not likely to attain 60 minutes of MVPA per day.

Almost 90% of the children with low actual MC did not meet the guideline of at least 60 minutes of MVPA per day. These findings are in line with previous studies which showed that children with impaired

motor competence, including children with developmental coordination disorder (DCD), have lower levels of physical activity²⁹. The children with low actual MC performed on average at the 8th percentile and thus were well below the 27th percentile cut off for low MC, indicating that at least some of these children might be at risk for DCD. Children with average or high actual MC were more likely to attain the MVPA guideline. Yet, even among these children, only a minority attained at least 60 minutes of MVPA per day (25% and 41% respectively). Consistent with previous literature, more boys (23%) than girls (10%) met the MVPA guideline³. The overall percentage of children in this sample meeting the MVPA guideline (16%) is noticeably lower than the 42% of American children in the same age group that were found to meet the guideline in the study by Troiano et al.⁴, which was a national representative sample of American children. The striking difference between the two samples in the percentages of children who reached 60 minutes of MVPA per day may be partially explained by the different cutoffs that were used to determine MVPA. Troiano et al.⁴ used the cutoff points as defined by Freedson et al.³⁰ to determine MVPA (>500 counts per minute), resulting in higher MVPA levels than if the cutoff points that were applied in the present study (Evenson et al.²⁴) would have been used (> 2296 counts per minute). It is also possible that, regardless of the cutoffs that were used, children in the present study were simply less physically active than those in the Troiano study⁴. Data for the Troiano study were collected in 2003 and 2004 and MVPA levels are known to have decreased, or in the best case to have stagnated in some countries, over the last decade³. Also possible is that a parallel secular decrease in MC (references for showing decreased MC) since 2003 would be partially responsible for the decreased PA levels over this same time frame, as only 8% of the current sample scored above the 65 percentile (TGMD-2 normative data from 2000). Furthermore, based on the current data, perhaps the vast majority of the 42% of children who met the 60 minute guideline in the Troiano study also were moderate- to highly-skilled children.

Overall, the percentage of children in the high MC group reaching the 60 minutes guideline was almost four times as high as the low MC group. As such, improving children's actual MC is suggested to result in overall higher MVPA levels across childhood and accordingly, more children attaining the MVPA guideline. However, it should be noted that even within the high actual MC group, less than half of the

children met the MVPA guideline. While motor competence is suggested to be an important mechanism driving physical activity engagement, it is not the only underlying mechanism and many other factors such as motivation to engage in physical activity, body weight status or parental support might affect children's actual engagement in physical activity. It is recommended that future research examining the proficiency barrier among children, takes these factors into account.

Although it was hypothesized that perceived MC would mediate the relationship between actual motor competence and the percentage of children meeting the MVPA guideline^{9,17,18}, the results of the present study do not provide evidence for the mediating role of perceived MC. In this regard, it must be noted that the majority of children in the present study (76%) had a low MC. The significantly positive relationship between children's perceived MC and their MVPA levels ($r = .17$) indicates that higher levels of perceived MC were related to higher levels of MVPA. However, it is possible that the effect of an increased perceived MC was insufficient to mediate the relationship between actual motor competence and the percentage of children meeting the MVPA guideline in this sample of children with overall low actual MC. It is recommended that future studies investigate whether there might be evidence for the mediating role of perceived MC in the relationship between actual motor competence and the percentage of children meeting the MVPA guideline in a sample of children with higher levels of actual MC.

A first limitation of the present study is its cross-sectional design, which does not allow us to conclude that an increase in children's actual MC will definitively result in more children meeting the MVPA guideline. A second limitation is the low number of children in the average and high actual MC group. Even though the study sample consisted of a relatively large and diverse group of 326 children, there was an over-representation of children with low actual MC. The large number of children with low actual MC levels may partially be explained by the fact that the majority of the children in the current study (52%) had a low socio-economic status, a factor which is negatively correlated with young children's actual MC³¹.

The main strengths of this study are the objective measurement of MVPA and the standardized cut-offs that were used to categorize the children as having low, average or high actual MC. The large sample size with participants from three different states in the U.S. is also a strength.

Conclusion

The present study provides evidence for the existence of a proficiency barrier related to actual MC, below which almost 90% of the children are not attaining the guidelines of 60 minutes of MVPA per day. These data support data by Stodden et al.¹⁵ who found support for a proficiency barrier in young adults (i.e., 18-25 yrs) and normative fitness levels. Despite the positive relationship between children's perceived MC and their MVPA levels, there is no evidence to assume that perceived MC mediates the relationship between actual motor competence and the percentage of children meeting the MVPA guideline in this age group (i.e., 7-12 yrs). Further research into the role of perceived MC is recommended in more motor competent samples.

Practical Implications

- An alarming number of children (76%) demonstrated low levels of actual MC with a mean percentile rank of 8%. Therefore, MC needs to be promoted.
- Among children with low actual MC, almost 90% of the children did not meet the MVPA guidelines thus this population of children needs specific strategies to address their low actual MC and MVPA.
- Children with high levels of actual MC were 2.5 times more likely to meet the PA guideline than their peers with lower levels of actual MC, thus emphasizing the need to develop children's MC.
- Special attention should be paid to girls when developing MC since boys were 1.9 times more likely to attain 60 minutes of MVPA per day than girls in this sample.

- Given the positive relationship between children's perceived MC and their MVPA, strategies targeting improvements in perceived MC are recommended.

Acknowledgements

This research was supported by the National Institutes of Health [R21HD055621-01A2].

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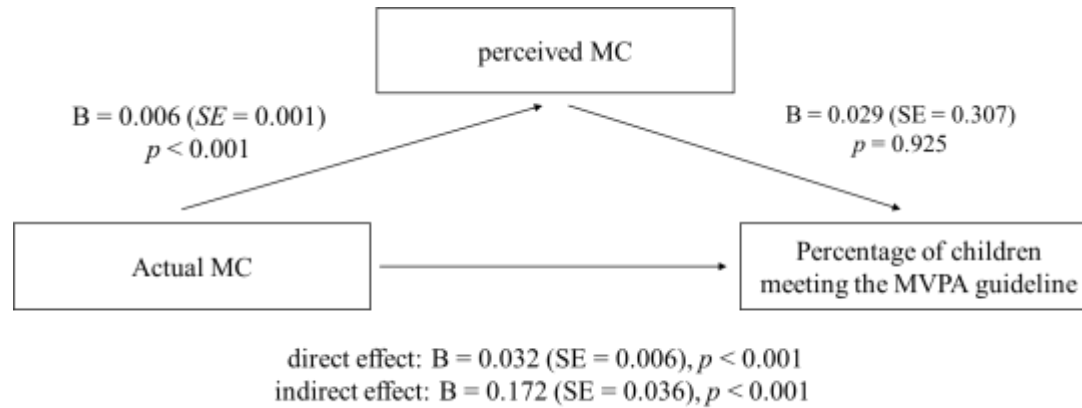
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Figures

Figure 1. The mediational relationship between actual MC, perceived MC, and percentage of children meeting the MVPA guideline



Tables

Table 1.

Descriptive statistics and correlations among variables (N=326)

Variables	<i>M</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>	<i>1</i>	<i>2</i>	<i>3</i>
1. Actual MC (percentile)	19.15	22.23	1.00	92.00			
2. Perceived MC (1-4 scale)	3.15	.57	1.67	4.00	.21***		
3. MVPA (min/day)	40.88	22.65	5.00	160.00	.31***	.17**	
4. Age (years)	9.49	1.26	6.92	11.83	.27***	-.34***	.05

Note. * $p < .05$; ** $p < .01$; *** $p < .001$.

Table 2.

Summary of Binary Logistic Regression Analysis for Variables Predicting the Percentage of Children Meeting the MVPA Guideline (n=326).

Variable	B	SE(B)	Exp(B)	95% CI		Sig. (p)
				Lower	Upper	
Sex (boy) ^a	.62	.17	1.86	1.33	2.61	< .001
Average actual MC ^b	.08	.27	1.08	.64	1.84	.763
High actual MC ^b	.90	.31	2.46	1.35	4.48	.003

Note. Reference category = 0; ^a 0 = girl; ^b 0 = low actual MC

Table 3.

Mean Actual MC Scores per Group and Percentage of Children Meeting the MVPA Guideline per Group (n=326).

Group	% of total	N	n girls	n boys	Actual MC (percentile)	Percentage meeting MVPA guideline		
						total	girls	boys
Low actual MC	76.07%	248	124	124	8.30 (7.92)	11.69%	8.07%	15.32%
Average actual MC	15.64%	51	28	23	42.55 (7.84)	25.49%	7.14%	47.83%
High actual MC	8.28%	27	16	11	74.59 (8.60)	40.74%	25.00%	63.64%
Total	100	326	168	158	19.15 (22.23)	16.26% (n=53)	9.52% (n=16)	23.42% (n=37)

Note. Values in parentheses are standard deviations.