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The Effect of Execution Surface on the Accuracy of Children's Perceived Motor Competence in Locomotor Skills: A Quasi-Experimental Study

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Original Article

Abstract

Introduction: Self-concept is a structured set of perceptions an individual holds about themselves, which undergoes significant changes during the transition from childhood to adolescence. The purpose of this study was to examine the effect of execution level on the accuracy of children's perceived motor competence in locomotor skills.

Materials and Methods: This research employed a quasi-experimental design with a pretest-posttest structure. The statistical population consisted of children from the city of Bandar Anzali, Iran. A sample of 64 children aged 6 to 8 years was selected via cluster sampling from local kindergartens and schools. Children's perceived motor competence was assessed using the Almeida maximum performance estimation method, and their actual competence was evaluated through the performance of locomotor skills, including horizontal jump, hopping, and skipping, on two surfaces: concrete and artificial grass. Statistical analyses were conducted using mixed analysis of variance (ANOVA) and Bonferroni post hoc tests in SPSS software with a significance level of 0.05.

Results: The results from the mixed ANOVA for the within-group effects across all three tasks, horizontal jump ($P < 0.001$), hopping ($P < 0.001$), and skipping ($P = 0.020$), showed that the main effect of task was significant. However, the interactive effects of task and age ($P = 0.250$), task and gender ($P = 0.320$), and the three-way interaction of task, age, and gender ($P = 0.750$) in horizontal jump skill were not significant. Similarly, for the hopping skill, the interactions of task and age ($P = 0.830$), task and gender ($P = 0.310$), and all three factors combined ($P = 0.370$) were not significant. For skipping, the interactions of task with gender ($P = 0.450$), and the combined effect of all three factors ($P = 0.51$) were also not significant. The only significant interactive effect was between task and age in skipping ($P < 0.001$). Between-group comparisons revealed significant main effects of age and gender only in the horizontal jump task.

Conclusion: Children were unable to perceive changes in their performance level while executing motor tasks. The findings indicated that the perceptual ability was influenced by age and gender, only in the horizontal jump task, underscoring the importance of considering this factor in studies of locomotor skills in children.

Keywords: Motor skills; Self-concept; Self-perception; Perceptual accuracy; Execution surface

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Introduction

Self-concept plays a vital role in everyday life and in educational environments, especially in physical education. From the perspective of various psychological disciplines, possessing a positive self-concept is regarded as a fundamental starting point for development (1). While preschool children are not yet able to see their abilities in a differentiated way, children in primary school develop a more accurate sense of their own skills. During this stage, social comparison with peers becomes more important, and as they grow, children learn to make more realistic assessments of their performance (2).

Actual motor competence refers to a person's ability to perform various motor skills, including locomotor skills (moving the body), object control (handling objects in space), and stability (maintaining balance) (3). These skills are essential for performing daily tasks such as walking, running, and jumping (4). In addition to actual motor competence, perceived motor competence refers to an individual's judgment of their own actual motor capabilities (5). This perception is considered the most important aspect of the physical self-concept domain and serves as a primary motivation for voluntary participation in sports or physical activities (6). Harter proposed that actual competence precedes perceived competence, which in turn influences physical activity and serves as a significant factor in a child's motivation (4). In the conceptual model of motor development proposed by Stodden et al. (2008), a direct relationship exists between actual motor competence and physical activity, alongside an indirect relationship mediated by perceived motor competence (7). According to this model, physical activity promotes the development of motor skills in early childhood, whereas in middle to late childhood, motor skills influence the development of physical activity (8).

Perceptions of motor competence affect emotions, motivation, and behavior. This concept relates to children's confidence in their ability to perform various motor skills, which underpins their participation in sports and physical activities both at school and during leisure time. However, perceived competence does not always match children's actual motor competence (9). Children use both internal and external feedback sources to gauge their perceived motor competence. According to Harter's competence motivation theory, internal sources might include effort or performance improvement, while external sources involve feedback from peer comparison and evaluative comments from significant others, usually parents and peers (10). Harter argues that individuals who perceive themselves as capable in a certain area and believe they have internal control are more likely to exhibit higher intrinsic motivation in that area (11). According to Harter's model, successfully executing skills or tasks, such as developing motor competence in sports, improves perceived competence. This, in turn, boosts motivational behaviors such as participating in physical activity and achieving tangible performance results, including motor skill proficiency. (12). Harter suggests that individuals, especially children, tend to engage in activities where they feel competent and avoid those where they don't feel successful (13). Designing practice environments that support athlete learning and enhance performance is a crucial consideration for sports practitioners. A common framework used to guide the design of such environments is the Constraints-Led Approach, proposed by Newell in 1986 (14). Constraints are boundaries or limitations related to the individual, environment, or task, which can either facilitate or restrict the motor patterns of a dynamic and complex system (5). Individual characteristics, combined with task requirements and environmental factors, influence motor performance outcomes. Although empirical evidence supporting the scaling of throwing equipment is limited, the Constraints-Led Approach offers a useful framework for designing such research. Manipulating task constraints, such as game rules, sports equipment, and playing space, allows individuals to develop specific functional movement sequences and decision-making skills, thereby promoting diversity and innovation (15) (Table 1).

Table 1. Task constraints

Task type	Surface type
Horizontal jump	Concrete and artificial grass
Hopping	Concrete and artificial grass
Skipping	Concrete and artificial grass

Perceived motor competence is influenced by individual constraints, including age and gender. Young children generally have higher perceptions of their physical competence, which tends to decline after early childhood (16). One possible explanation for children's tendency to overestimate their abilities relates to their limited metacognitive skills. These skills involve understanding cognitive processes and the factors that influence them, helping individuals develop more accurate self-perceptions (15). Gender also impacts perceived motor competence in young children. Studies suggest that differences in perceived motor competence between boys and girls mirror actual differences in motor competence, with boys typically reporting higher perceived competence than girls (16, 17). The decline in perceived motor competence over time is similar for both sexes; however, boys start with a higher level of perceived competence, creating a cascading effect. As a result, boys consistently demonstrate higher perceived athletic competence than girls throughout their education, from primary to high school (16, 17). Various studies use different models and measurements to assess perceived motor skills, which makes comparing results challenging. Additionally, most past research has primarily examined how individual factors, such as age and gender, affect children's perceived motor competence. However, less attention has been given to environmental factors, such as the type of performance surface and cultural influences, as well as the combined effects of age and gender. Therefore, this study aimed to assess how accurately children perceive their competence in locomotor skills on different surfaces and to compare these perceptions across various age and gender groups.

Materials and Methods

The present study included 64 children (33 boys and 31 girls) across three age groups: 6, 7, and 8 years old. Participants were selected through cluster sampling from kindergartens and primary schools in Anzali. The sample size was determined using Gpower software (Version 3.1.9.7, University of Düsseldorf, Germany), based on parameters including a minimum 80% power, a significance level of 0.05, and an effect size of 0.40. Inclusion criteria were: age between 6 and 8 years, no underlying diseases (18), no injuries in the past month, no disabilities preventing independent test participation, and no illness in the previous week (7). Exclusion criteria included lack of cooperation, failure to perform the task, unwillingness to continue participation, and the occurrence of unexpected illness (19). Prior to testing, ethical considerations were addressed, including obtaining informed consent from parents, confirming the child's ability to understand the test content, creating a safe and supportive environment, and ensuring no abuse or pressure during the testing process. This study was approved by the Ethics Committee of the Sport Sciences Research Institute (IR.SSRC.REC.1402.311).

Almeida et al. conducted a study to assess perceived motor competence in children using a maximal performance estimation method (20). In the current study, children were asked to assess their abilities prior to executing the various motor skills.

Following verbal instructions and a demonstration of the horizontal jump technique to assess perceived motor competence, the children stood beside a 50-meter tape measure at the starting line on both concrete and artificial grass surfaces. They estimated the distance they believed they could jump on each surface, which was recorded as their perceived motor competence. To measure actual motor competence in the horizontal jump, the child was first asked to stand behind the starting line on the artificial grass surface. Upon the verbal command "jump," the child executed a horizontal jump to achieve maximum distance. The distance from the back of the starting line to the back of the child's heel at the landing point was measured and recorded as the actual motor competence for that surface. This same procedure was then repeated on the concrete surface (Figure 1).

Figure 1. Performing the horizontal jump task at two different levels

The researcher first explained and demonstrated the correct technique for both hopping (jumping and landing on the same foot) and skipping (a continuous step-hop pattern). To measure perceived competence, participants stood beside the 50-meter tape measure at the starting line on both the concrete and artificial grass surfaces. They estimated the distance they could cover while performing each skill on each surface, and these estimates were recorded as their perceived motor competence. For assessing actual hopping competence, the child was instructed to stand behind the starting line on the artificial grass surface. On the command "begin," the child hopped continuously for as long as possible. The distance from the starting line to the final point, where the child maintained a rhythmic and alternating hopping pattern (i.e., the point at which hopping ceased), was measured and recorded as the actual hopping competence on artificial grass. This protocol was then repeated on the concrete surface.

To measure actual skipping competence, the child was instructed to stand behind the starting line on the artificial grass surface. On the command "begin," the child skipped continuously for maximum distance. The distance from the starting line to the final point where the child maintained the rhythmic, alternating step-hop pattern of skipping was measured and recorded as the actual skipping competence on that surface. This procedure was also repeated on the concrete surface.

The independent variable involved manipulating the environmental surface (artificial grass vs. concrete). The dependent variables were perceived motor competence and actual motor competence in the horizontal jump, hopping, and skipping tasks. Perceived competence served as the predictor variable, and actual competence served as the criterion variable.

Means and standard deviations were calculated for perceived competence, actual motor competence, and absolute percent error across the three age groups, separated by gender, for each of the different motor tasks. A Mixed Model Analysis of Variance (Mixed ANOVA) was used to compare the error between perceived and actual competence across the two performance surfaces (within-group differences) and to assess performance differences across ages and genders (between-group differences), as well as the interaction of time (Task × Age × Gender). The design involved a 3-way interaction between Group (6, 7, 8 years old) and Gender (Boys vs. Girls).

Absolute Percent Error (APE) was determined using the following formula (Equation 1):

$$\left| 1 - \frac{\text{Perceived Competence}}{\text{Actual Competence}} \right| \times 100$$

This method aligns with approaches used by Almeida et al. in 2017 (20) and 2023 (21). It measures the magnitude of judgment error as a percentage of actual performance, indicating the size of the error without specifying direction (overestimation or underestimation). Post-hoc analyses were conducted using the Bonferroni correction to reduce the risk of Type I error in multiple comparisons. All statistical analyses were performed using SPSS version 27 (IBM Corp., Armonk, NY, USA), with a significance level of 0.05.

Results

Sixty-four children were selected via cluster sampling from preschools and elementary schools in Bandar Anzali (with an additional four subjects initially recruited to account for potential attrition). As no children withdrew, the final sample consisted of 31 girls and 33 boys aged 6–8 years.

The perceived competence record and the movement of competence across three age groups, broken down by gender, are shown in Table 3.

Table 4 presents the absolute error rate between perceived and actual motor competence in three age groups, across two gender groups, and within each age group for both genders.

In this study, mixed variance analysis was employed to examine differences in absolute percentage error between perceived and actual motor competence across task types, age groups, and genders.

Table 2. Demographic Information for the 3 Age Groups (Girls and Boys)

Variable	Age (year)	Girl	Boy	P-value (Difference between genders)
Height (cm)	6	116.66 ± 3.28	118.25 ± 4.73	0.020
	7	115.77 ± 1.39	125.45 ± 3.53	≤ 0.001
	8	125.30 ± 4.80	133.70 ± 3.40	≤ 0.001
	Total	118.93 ± 5.15	125.30 ± 9.12	≤ 0.001
P-value within-group difference		≤ 0.001	≤ 0.001	
Weight (kg)	6	18.83 ± 3.80	27.33 ± 2.93	≤ 0.001
	7	21.11 ± 2.61	28.63 ± 5.10	≤ 0.001
	8	28.80 ± 4.15	36.20 ± 5.37	≤ 0.001
	Total	22.61 ± 5.41	30.45 ± 6.06	≤ 0.001
P-value within-group difference		0.030	0.020	

Table 3. Perceived competence and actual motor competence across three age groups by gender

Variable	Age (year)	Girl	Boy	P-value (Difference between genders)
Horizontal jump task (cm)	6	112.75 ± 23.47	140.41 ± 18.97	≤ 0.001
	7	128.77 ± 22.57	164.63 ± 36.32	≤ 0.001
	8	119.40 ± 13.22	124.20 ± 48.94	≤ 0.001
	Total	119.54 ± 20.84	143.57 ± 40.57	≤ 0.001
P-value within-group difference		0.050	0.030	
Hopping task (cm)	6	1370.00 ± 517.45	1820.83 ± 1862.97	0.050
	7	1418.88 ± 565.87	2220.90 ± 973.60	0.030
	8	2362.00 ± 376.52	2295.00 ± 839.46	0.010
	Total	1704.19 ± 1068.42	2131.21 ± 1320.73	0.030
P-value within-group difference		0.020	0.040	
Skipping task (cm)	6	1111.25 ± 339.62	1720.83 ± 2318.25	≤ 0.001
	7	1665.55 ± 458.86	1850.00 ± 416.53	≤ 0.001
	8	1715.00 ± 648.09	1430.00 ± 417.69	≤ 0.001
	Total	1466.93 ± 554.43	1675.75 ± 1407.40	≤ 0.001
P-value within-group difference		0.040	0.010	

Table 4. Absolute percentage error between perceived and actual motor competence based on mixed analysis of variance

Source	F	P-value	Eta squared
Horizontal jump	62.79	≤ 0.001*	0.52
Task * Age	1.42	0.25	0.04
Task * Gender	0.96	0.32	0.01
Task * Age * Gender	22.73	0.75	0.02
Hopping	9.84	≤ 0.001*	0.14
Task * Age	0.18	0.83	0.00
Task * Gender	1.04	0.31	0.01
Task * Age * Gender	0.98	0.37	0.03
Skipping	5.66	0.02*	0.08
Task * Age	5.35	≤ 0.001*	0.15
Task * Gender	0.55	0.45	0.01
Task * Age * Gender	0.67	0.51	0.02

*Significant difference at the P<0.001 level.

For the horizontal jump task, the F-statistic associated with the task effect was 62.79, indicating a statistically significant difference (P < 0.001) with an effect size of 0.52. These findings suggest that children have a limited capacity to perceive changes in the level of the horizontal jump task. The interaction between task and age was not statistically significant (F = 1.42, P = 0.250), with an effect size of 0.04, indicating that the task's effect does not vary significantly across different age groups. Similarly, the interaction between task and gender was not significant (F = 0.96, P = 0.320), with an effect size of 0.01. The interaction effect of horizontal jump, age, and gender also showed no significant effects (F = 22.73, P = 0.750), with an effect size of 0.02.

Results pertaining to the hopping task revealed an F-value of 9.84 for the main effect of the task, which was statistically significant (P < 0.001) and had an effect size of 0.14. These results indicate that children failed to perceive changes in the ground surface during the hopping task. The interaction between task and age was not significant (F = 0.18, P = 0.830), with an effect size of 0.00, suggesting no variation in task perception based on age. The interaction between task and gender was also non-significant (F = 1.04, P = 0.310), with an effect size of 0.01. Furthermore, the three-way interaction among task, age, and gender was not significant (F = 0.98, P = 0.380), with an effect size of 0.03.

Regarding the skipping task, the effect of the task was statistically significant (F = 5.66, P = 0.020) with an effect size of 0.15. Additionally, the interaction between task and age was significant (F = 5.35, P < 0.001), with an effect size of 0.15, indicating that perception of level change varies with age. The interaction between task and gender was not significant (F = 0.55, P = 0.450), nor was the three-way interaction among task, age, and gender (F = 0.67, P = 0.510), with an effect size of 0.02, suggesting no combined effect of these factors.

Post-hoc Bonferroni analyses identified a significant difference between the 6- and 8-year-old groups, specifically in the horizontal jump task (Mean Difference = 12.10, SD = 4.15, p = 0.01). No other tasks demonstrated significant differences across age groups.

Discussion

This study aimed to examine the accuracy of children's perceived motor competence in locomotor skills across various environmental conditions, considering different age and gender groups. The results from the Mixed ANOVA regarding within-group effects showed that the main effect of the task was significant for all three skills (horizontal jump, hopping, and skipping). However, interaction effects for Task, Age, and Gender were not significant, except for the Task × Age interaction in the skipping skill. Between-group comparisons revealed a significant main effect of age only for the horizontal jump.

Executing tasks in different environments led to notable differences in participants' overall performance, suggesting an inability to adjust perceived skills based on the type of surface. However, age was a significant factor in the horizontal jump, with clear differences between age groups. Gender did not significantly influence perception accuracy (error magnitude), as no notable differences were found between boys and girls in task error rates. The link between motor performance levels and perceived motor competence, specifically, the accuracy of estimation, has been primarily studied by Almeida et al., who investigated estimating fundamental motor skills in real-world settings (20, 21). Nonetheless, this area remains underexplored in existing literature. A systematic search found no studies specifically examining how the performance surface affects children's perceived competence accuracy. Most prior research has assessed perceived motor competence using self-report questionnaires, as seen in studies by Khodaverdi et al. (22) and Barnett et al. (23). This limitation restricts direct comparison with the present findings, necessitating interpretation through related studies. Previous research has shown that children often overestimate their physical abilities, which can lead to failed attempts or injuries (24, 25). Conversely, underestimating their skills may discourage participation in physical activities and sports (26). This study, conducted in a controlled setting, suggests that both groups may have overestimated their ability due to the safe environment and low injury risk (20). Castelli et al. (27) examined the relationship between perceived and actual motor skills in sports such as basketball and throwing, finding a correlation of 0.57 in throwing; however, assessment methods and participant age may influence this result. The relationship between actual and perceived motor competence is affected by physical factors (age, gender, BMI, activity level), psychological factors (motivation, enjoyment) (28), and socio-environmental factors (socioeconomic status) (29). Results showed a significant difference in absolute percent error among the three age groups in the horizontal jump. As children grow older, their perception of their motor skills tends to align more closely with their actual ability, highlighting the role of age in developing perceived competence (13). In younger children (6-7 years), boys often have better object control skills than girls; girls may underestimate their abilities, while boys tend to overestimate (4). The developmental theory by Stodden et al. emphasizes age as a moderator between actual motor skills and perceived ability. Young children often overestimate their skills because they cannot distinguish between ability, intelligence, and effort as factors in success (30). Barnett et al. (31) found that both actual and perceived abilities were lower in young girls compared to boys, particularly in object control, which was also associated with lower physical activity levels. While gender differences in perceived competence are typically evident (with boys scoring higher), this study suggests that the accuracy of perception (i.e., the error) did not differ significantly between genders in this context.

Findings showed that increasing task difficulty by using artificial grass instead of a solid surface did not significantly change the absolute percent error in children's perception compared to their actual ability in hopping, skipping, and jumping tasks. When the surface type changed, participants maintained a relatively stable error percentage. This may be because children have limited practice with these specific skills on these surfaces in daily life. The primary strength of this study lies in measuring competence through direct, task-relevant performance measures.

Researchers argue that perception-action relationships occur in real-world settings, so perceived competence should be evaluated in these authentic contexts. Additionally, tests should be simple and practical, as preschool and physical education teachers typically prefer assessments that require minimal expensive equipment and are easy to score.

Limitations

Despite the valuable findings, this study had some limitations. First, it used a cross-sectional design. A longitudinal study following the same children over time would offer a better understanding of how perceptual-motor accuracy develops. Second, the sample was restricted to children in Bandar Anzali, which may limit the applicability of the results to other populations due to unique cultural or environmental factors. Additionally, variables such as daily physical activity, previous experience on different surfaces, and familiarity with specific motor tasks were not controlled, and these factors could have influenced the outcomes. Lastly, the discussion was limited by the lack of directly comparable domestic and international research.

Recommendations

Future research should replicate this study with larger, more diverse samples from different geographical and cultural regions. Future studies could explore the effects of changing other task constraints (such as obstacle height or distance) and environmental factors (like sand or wood surfaces). Investigating this phenomenon in object control skills (such as throwing and catching) would help determine if these findings apply to other skill areas. Additionally, incorporating direct assessment tools for children's metacognitive skills could clarify the cognitive mechanisms behind the accuracy of perceived motor competence.

Conclusion

The study showed that, despite significant differences and a lack of similarity in error rates across different surfaces, children could not accurately detect changes in the performance surface when performing tasks. Additionally, the results suggested that children's perception of surface changes in most tasks was not significantly affected by age or gender, except for the horizontal jump, where age had a notable influence. Still, more research is needed to fully understand the mechanisms behind these age- and gender-related differences.

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Authors' Contribution

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Attracting financial resources for the project: -

Project Support Scientific and executive services: Shahab Parvinpour, Mohsen Shafizadeh

Providing equipments and statistical sample: Younes Mosadegh, Abbas Bahram

Data collection: Younes Mosadegh, Shahab Parvinpour

Analysis and interpretation of the results: Younes Mosadegh

Specialized statistics services: Younes Mosadegh

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Maintaining the integrity of the study process from the beginning to the publication, and responding to the reviewers' comments: Younes Mosadegh, Shahab Parvinpour, Abbas Bahram, Mohsen Shafizadeh

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Conflict of Interest

The authors did not have a conflict of interest.

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