DR KARA PALMER (Orcid ID : 0000-0003-0587-6776)

Article type : Original Article

Examining the Psychometric Properties of the Digital Scale of Perceived Motor Competence in young children

Leah E. Robinson[a] & Kara K. Palmer[a]

[a] Child Movement, Activity, and Developmental Health Laboratory, School of Kinesiology, University of Michigan, Ann Arbor, MI, USA

Corresponding Author

Leah E. Robinson
830 N University Ave
School of Kinesiology, University of Michigan
Ann Arbor, MI 48109
lerobin@umich.edu

Acknowledgments

We thank Ms. Katherine M. Chinn for her assistance with data collection and Mr. Michael A. Nunu for his assistance with the referencing of this manuscript. Funds from the University of Michigan Momentum Center for Childhood Obesity supported this project.

Data Availability

The data that support the findings of this study will be available upon request after signing a data usage agreement with the PI. Potential users of the data must agree to conditions of use, including but not limited to: restrictions against attempting to identify study participants, reporting responsibilities, and proper acknowledgment of the data resource.

Abstract

This study examined the psychometric properties (i.e., reliability and validity) of the Digital Scale of Perceived Motor Competence (DSPMC) in preschool-aged children. 118 children (M_{age}=4.5) completed Study 1 on internal consistency and test-retest reliability, and 87 children (M_{age}=4.5) completed Study 2 on the construct validity of the DSPMC. Study 1 results support that the DSPMC demonstrates an acceptable internal consistency at both the initial (α=0.78) and retest (α=0.75) and good test-retest reliability (ICC=0.84; 95% CI=0.76-0.89). Study 2 results demonstrate that the DSPMC is significantly correlated to two other measures of perceived competence (r_{range}=0.25-0.39) and all actual motor skill subscales (r_{range}=0.23-0.39). These results support that the DSPMC is a valid and reliable tool to measure perceived competence in young children.

Keywords: Self-perceptions, Psychometrics, Pediatrics, Preschool, Movement

1. Introduction

Perceived motor competence, how well a child thinks they move, is an important construct relating to young children's physical activity[1-2] and motor competence.[3-4] Perceived motor competence at a young age is likely attributed to effort and not actual skills or abilities as young children cannot differentiate between ability and effort.[5-7] Therefore, perceived motor competence is often high as children are unable to accurately assess and overinflate perceptions of their own abilities.[5-7] Conceptual models propose that perceived motor competence supports physical activity and motor skills in early childhood; therefore, children who think they are better movers will engage in more physical activity and have better motor skills.[3-8]

While conceptual models have sparked interest in perceived motor competence, empirical evidence continues to build on perceived motor competence itself as well as its relationship to health outcomes. Perceived motor competence has been shown to have a positive relationship with actual motor skill competence.[4] Research supports that perceived competence is associated with children and youth's motivation to engage in physical education[9] and physical activity.[10] Perceived competence exhibits the most robust relationship between any measure of self-concept and physical activity behaviors in children and adolescents.[1] Longitudinal data also support that perceived sports competence (i.e., a child's self-perception on their sports ability) mediates the

relationship between actual motor competence in childhood (10.1 yrs) and self-reported physical activity engagement during adolescence (16.4 yrs).[11] Further, children's perceived object control skill competence predicts their physical activity engagement 8 years later.[12] Intervention research supports that young children's perceived motor competence at the start of an intervention predicts skill gains in locomotor and total motor skills across a motor skill intervention.[13] Therefore, the construct of perceived motor competence is important and relates to various health outcomes and movement behaviors in children and youth.

It is imperative to measure perceived motor competence effectively. For the past 30 years, the Pictorial Scale of Perceived Competence and Social Acceptance of Young Children (PSPCSA) has been the primary tool to assess perceived physical competence, which served as a proxy for perceived motor competence.[5] This scale includes six items: swinging, climbing, tying shoes, running, skipping, and hopping. A second assessment, the Pictorial Scale of Perceived Movement Skill Competence (PMSC), was created in 2015 to assess perceived motor competence specifically.[14-15] The PMSC includes twelve fundamental motor skills that align with one of the most commonly used motor skill assessments, The Test of Gross Motor Development-2nd Edition.[16] These skills include six locomotor skills (run, gallop, hop, leap, jump, slide) and six object control or ball skills (throw, catch, kick, dribble, roll, two-handed strike). Both assessments use similar administration protocols whereby children are presented with two static pictures-one of a highly skilled child and one of a less skilled child- and are asked to point to the picture that looks most like them. After making this choice, children are prompted to choose to what extent they can perform the skill shown. This response results in a quantitative score, with a higher score being associated with higher perceived competence.

Without a doubt, the literature and field have greatly benefited from these assessments, but still, these assessments are limited in that both use a static picture to represent movement, a dynamic process. The Digital Scale of Perceived Motor Competence (DSPMC) uses digital clips instead of static pictures when displaying poor and skilled performances. The DSPMC is a valid and reliable scale to assess perceived motor competence in school-aged children.[17] However, the reliability and validity of this assessment have yet to be examined in a preschool population. It is essential to understand the reliability of the DSPMC in a younger population as research supports that preschool-aged children (3-5 yrs) cannot accurately perceive their actual abilities and often

display inflated self-perceptions.[18] The preschool years are also a time where perceived motor competence is malleable and improves after engagement in certain motor programming or interventions.[19-21] Therefore, research is needed to validate the DSPMC in this population. The purpose of the present investigation was to address this need and examine the psychometric properties of the DSPMC in preschoolers. Study 1 examined internal consistency and test-retest reliability of the DSPMC, and Study 2 examined construct validity in two ways: (a) examining how the DSPMC related to two other measures of perceived motor competence, and (b) examining how the DSPMC related to actual motor skill competence.[22]

2. Materials & Methods

2.1 Participants

The sample for Study 1 (test-retest reliability and internal consistency) included 118 preschoolers (M_{age} = 4.5, SD = .59, 50.2% boys) from three university-sponsored childcare centers in the United States. The racial composition of this sample was 38.1% Caucasian American, 24.6% African American, 20.3% Asian American, 14.4% Other/Mixed, and 2.5% Hispanic.

The sample for Study 2 (construct validity) included 87 preschoolers (M_{age} = 4.5 SD = .64; 48% boys) from two university-sponsored childcare centers in the United States. The racial composition of this sample was 47.1% Caucasian American, 27.6% Asian American, 5.7% African American, 17.2% Other/Mixed, and 2.3% Hispanic.

2.2 Measures

2.2.1 Digital-Scale of Perceived Motor Competence. The DSPMC is a digital-based assessment that allows individuals to view motor skills in four dimensions—*height, width, depth,* and *time.* The ability to view movement in four dimensions is critical since movement is a dynamic action rather than a static act.[17] The assessment included twelve motor skills: six locomotor skills (run, gallop, hop, leap, jump, and slide) and six object control or ball skills (throw, catch, kick, dribble, roll, and two-handed strike). These skills are also used in common motor skill assessments (e.g., the Test of Gross Motor Development-2[16]). In this assessment, children were presented with two digital clips of a model (LER) performing each skill. All 3-6 second clips were displayed on a small touchscreen tablet (9.5 x 7.3 inches). One clip depicted

an immature/unskilled motor skill performance, whereas the other displayed a mature/skillful motor skill performance. Children sat down one-on-one with a member of the research team who provided the following verbal prompts: "*Watch the following videos and touch the circle under the video where the person moves like you*." Each child was provided with one initial prompt, and, if requested, he/she could receive up to one additional prompt. Children watched both clips from left to right on the tablet, and clips were ordered so that half of the skills children saw the skilled performance first and the other half saw the unskilled performance first. The ordering of the skills and presentation was identical to the PMSC. [11,14] After watching both clips, children selected the clip in which the person moved like them, and after this initial selection, the selected circle disappeared was replaced by a smaller and larger circle. Follow-up questions were dependent on the initial selection. If a child touched the circle under the unskilled motor skill performance, they were asked, "*Are you not too good at [insert name of skill]*? [large circle] OR *Are you sort of good at [insert name of skill]*? [smaller circle]". If a child touched the circle under the skilled motor skill performance, they were asked, "*Are you pretty good at [insert name of skill]*? [smaller circle] OR *Are you really good at [insert name of skill]*" [larger circle]". The final circle selected flashed red after the final selection was made. Each response corresponded with a numerical value ranging from 1 (cannot do this skill) to 4 (really good at this skill). See Figure 1 for an example of how the assessment appears on the screen. The entire assessment took approximately 5-7 minutes to complete. Face validity of the DSPMC has been established, and research supports the DSPMC has acceptable validity (α= 0.68) and reliability (ICC 0.83, range 0.71–0.90) in elementary-aged children.[17]

---Insert figure 1 here---

2.2.2 Pictorial Scale of Perceived Movement Competence. The PMSC was created in 2015 by Barnett and colleagues.[11,14] The assessment was designed to create a picture-based perceived motor competence assessment that aligned with current measures of motor skills. The scale has a boy and girl version that both include twelve motor skills[16]: six locomotor skills (run, gallop, hop, leap, jump, and slide) and six object control or ball skills (throw, catch, kick, dribble, roll, and two-handed strike). Each page of the PMSC featured two pictures of a child completing a motor skill - one picture of a skilled performance and one picture of an unskilled performance. The order of appearance was counterbalanced across the assessment so that half of the time the

skilled picture was presented first. Assessors pointed to a picture and said, "*This (boy/girl) is pretty good at throwing*," and then pointed to the other picture and said, "*But this (boys/girl) isn't very good at throwing. Which (boy/girl) looks like you*?" After the child made their initial selection, they received a second prompt. If they selected the picture with the skilled performance, they were asked, "*Are you really good?* or *pretty good*?" If they selected the picture with the unskilled performance, they were asked, "*Are you not good* or *sort of good*?" Each response corresponded with a numerical value ranging from 1 (not too good at this skill) to 4 (really good at this skill). Face validity of the PMSC was established in earlier work, and the assessment has an alpha of 0.60 - 0.73 and an ICC 0.83 (0.60 - 0.93).[11,14]

2.2.3 Pictorial Scale of Perceived Competence and Social Acceptance of Young Children. The Pictorial Scale of Perceived Competence and Social Acceptance of Young Children (PSPCSA) was created by Harter and Pike and examines perceived competence in young children.[5] This assessment includes four subscales measuring individual constructs of perceived competence: physical, cognitive, social acceptance, and maternal acceptance. Each subscale consists of six questions/skills that vary according to the child's age. The physical subscale has been used to measure perceived motor competence in preschoolers[19,23] and includes the skills swinging, climbing, tying shoes, running, skipping, and hopping.[5] For each skill, the children were presented with two static pictures: one of a highly skilled child and one of a less skilled child. Children were asked to look at the two pictures while listening to an administrator verbally describe each picture. Children were then asked, "*Which picture is more like you?*" If they selected the picture with the child who is more skilled, they were asked, "*Are you really good? or pretty good*?" If they selected the picture with the child who was less skilled, they were asked, "*Are you not good or sort of good*?" After making this choice, children were again prompted to choose to what extent they could perform the skill shown. This response resulted in a quantitative score between 1 - 4 with 4 representing the most skilled and 1 representing the least skilled. The assessment has a low to acceptable alpha (α = 0.66 - 0.71) for perceived physical competence.[5]

2.2.4 Test of Gross Motor Development. Motor skills were assessed with the Test of Gross Motor Development-2nd Edition (TGMD-2).[16] The TGMD-2 is a criterion- and norm-referenced standardized assessment used to measure fundamental motor skills in children ages 3-10 years

old. The TGMD-2 assesses two broad categories of motor skills: locomotor skills (i.e., ability to propel the body through space) or object control skills (i.e., ability to propel or manipulate objects with the hands and feet). The six locomotor skills are run, jump, leap, hop, gallop and slide; the six object control skills are throw, strike off a tee, catch, kick, roll, and dribble. For each skill, three to five performance skill criteria are measured. For example, one performance criterion for running was that 'arms move in opposition to legs, elbows bent'. A "1" is scored if the performance criterion was successfully completed, and a "0" if the performance criterion was not successfully completed. When testing, children were given a visual demonstration of a skill execution that includes all skill criteria followed by one practice trial and two test trials for each skill. The highest total raw score a child could receive was a 96 (i.e., a maximum of 48 for both the locomotor and object control skill components). Mean test-retest reliability coefficients for the TGMD-2 subscales are: 0.96 (locomotor) and 0.97 (object control).[16]

2.3 Procedures

Both parental consent and child assent were obtained before inclusion in the sample. In Study 1 (internal consistency and test-retest reliability), preschoolers completed the DSPMC at two different time points: initial test and retest. The retest was completed 4-5 days after the initial test.[24] Two trained research personnel with previous experience using the DSPMC completed all the assessments, and the same researcher administered the initial and retest assessment to the same child to minimize external factors that might influence performance.[25-26] To eliminate an ordering effect, the skill order was reversed from the initial and retest assessments. Preschoolers in Study 2 (content validity) completed the DSPMC, PSPCSA, PMSC, and TGMD. The PMSC was completed at least two days after the DSPMC day due to similarities in skills between assessments. Preschoolers completed the TGMD one week after their last perceived competence assessment.

2.4 Statistical Analysis

Internal consistency for the DSPMC was assessed in two ways, Cronbach's alpha and McDonald's omega, to address concerns regarding potential violations of tau-equivalence required by Cronbach's alpha. Cronbach's alpha and interpreted values as an alpha (α) of ≥ 0.60 to be acceptable.[27] Test-retest reliability was examined using interclass correlations (ICC). ICC were calculated using a two-way random-effects model with a consistency agreement. ICC

values were interpreted as: poor agreement as < 0.50; moderate agreement as 0.50 - 0.75; good agreement as 0.76 - 0.89, and excellent agreement as ≥ 0.9.[28]

Average scale scores served as the perceived competence outcome variables for all analyses. The PSPCSA included only one average scale score across the six skills, but the DSPMC and PMSC had a total average scale score (12 skills), locomotor average scale score (6 skills), and object control scale score (6 skills). TGMD-2 raw scores (total, locomotor, and object control) were used in analyses. Pearson's correlation analyses were used to examine the relationship between actual motor skills and perceived motor competence as well as the relationship among the three perceived competence scales. All analyses were conducted in SPSS version 24, and alpha levels were set to 0.05 a priori.

3. Results

Due to absences and non-compliance, not all preschoolers completed all measures. A total of 117 preschoolers completed the initial DSPMC, and 115 completed the retest for Study 1. In Study 2, 86 preschoolers completed the PSPCSA, 80 completed the PMSC, and 85 completed the TGMD-2.

3.1 Study 1: Internal Consistency and Test-Retest Reliably

DSPMC internal consistency values for all skills were acceptable for the full sample for both the initial (α = 0.78, ω = 0.75) and retest (α = 0.75, ω = 0.76; see Table 1). When divided by skill subtest, internal consistency values varied for locomotor and object control skills at the initial (α = 0.66, ω = 0.62; α = 0.53, ω = 0.55; respectively) and retest (α = 0.58, ω = 0.60; α = 0.54, ω = 0.57; respectively). Results revealed good test-retest reliability for the full scale (ICC = 0.84; 95% CI=0.76 - 0.89), locomotor (ICC = 0.77; 95% CI= 0.66 - 0.84), and object control subtest (ICC = 0.72; 95% CI = 0.60 - 0.81).

--- Insert Table 1 ---

3.2 Study 2- Construct Validity

Table 2 provides descriptive statistics for each assessment. Significant correlations were present for all but one of the perceived competence measures (see Table 3). There was a positive relationship between the PSPCSA and the DSPMC on total ($r = 0.32$, $p < 0.01$), locomotor ($r = 0.31$, $p < 0.001$), and object control ($r = 0.25$, $p < 0.001$) subscales. There was a moderate,

positive relationship between PSPCSA and the PMSC total ($r = 0.55$, $p < 0.001$), locomotor ($r = 0.42$, $p < 0.001$), and object control ($r = 0.56$, $p < 0.001$) subscales. The total DSPMC score was positively related to the total ($r = 0.37$, $p < 0.01$), locomotor ($r = 0.35$, $p < 0.01$), and object control ($r = 0.32$, $p < 0.01$) subscales of the PMSC. The locomotor subscale score of the DSPMC was positively related to the total ($r = 0.39$, $p < 0.001$), locomotor ($r = 0.36$, $p < 0.01$), and object control ($r = 0.34$, $p < 0.01$) subscales of the PMSC. Lastly, the object control subtest of the DSPMC was related to total ($r = 0.26$, $p < 0.05$) and locomotor ($r = 0.25$, $p < 0.05$) subscales of the PMSC but not the object control subscale.

-- Insert Table 2 & 3 ---

Correlation analyses revealed that the total, locomotor, and object control subscales scores on the DSPMC were positively related to TGMD total ($r_{range} = 0.29 – 0.38$), TGMD locomotor ($r_{range} = 0.24 - 0.29$), and TGMD object control ($r_{range} = 0.23 – 0.39$). The total, locomotor, and object control subscale scores on the PMSC were related to TGMD total ($r_{range} = 0.24 – 0.28$) and TGMD locomotor ($r_{range} = 0.23 – 0.33$). Lastly, the PSPCSA was positively related to TGMD total ($r = 0.25$, $p < 0.05$) and TGMD locomotor ($r = 0.23$, $p < 0.05$). See Table 4 for a full list of all correlations.

--- Insert Table 4 ---

4. Discussion

Perceived motor competence is an important component of developmental trajectories of health.[3,8] Understanding and measuring perceived motor competence in childhood is essential and can provide valuable information when establishing healthy habits and developmental trajectories. The DSPMC is a different, modern approach to measuring perceived motor competence. The DSPMC uses digital clips and allows individuals to view the complete execution of motor skills concerning *height, width, depth,* and *time.* This scale was originally developed to be displayed using a video or digital performance and align with assessment tools used to measure motor skills in young children.[17] The purpose of this study was to examine the psychometric properties of the DSPMC in preschoolers.

This study supports that the DSPMC has acceptable internal consistency for both the total score and the locomotor subscale. While the internal consistency for the DSPMC object control

skills fell below the acceptable threshold for the full sample, this subscale did have acceptable internal consistency at the initial measure for boys (α = 0.60) and at the retest for girls (α = 0.60, ω = 0.79). The DSPMC total (i.e., all 12 skills) internal validity values are higher than those reported for the physical subscale of the PSPCSA in preschool (α = 0.66), kindergarten (α = 0.55), and both age groups combined (α = 0.62).[5] Further, the internal validity values were also greater than or similar to values established in previous work for older children with both the DSPMC (α = 0.42 - 0.68)[17] and Barnett et al.'s PMSC (α = 0.60 - 0.81).[14] We speculate that the current internal consistency values may be higher than previous work on the DSPMC due to the preschool version taking a 2-level approach rather than a 3-level. The 3-level approach used in an early paper included a poor, intermediate, and skilled performance of each motor skill,[17] whereas the 2-level approach used here only included a poor and a skilled performance of each skill. A 3-level approach was adopted in earlier work based on interview responses from school-aged children (M_{age} = 8.7 years SD = 0.5 yrs) during the face validity portion of the DSPMC.[17] A two-level approach was used in this present study to align with other scales used in preschool-aged children.[5,14] Additionally, this approach was deemed appropriate since face validity was previously established for the 2-level approach[17], and this approach mirrors the structure of other perceived competence measures in this population.[5,11,14]

Results from this present investigation also support that the DSPMC has good test-retest reliability in preschool-aged children. ICC values for the total sample were more than sufficient regarding the total (ICC = 0.84) and locomotor subtest (ICC = 0.77). The ICC for the object control subtests was moderate for the total sample (ICC = 0.72) and in both boys (ICC = 0.70) and girls (ICC = 0.74). The test-retest reliability in this present study is similar with older children with DSPMC (ICC = 0.83 - 0.75)[17] and the PMSC (ICC = 0.83 - 0.78).[14] In general, children tend to exhibit low reliability and consistency for locomotor skills with Barnett et al.'s PMSC in contrast to the DSPMC, which has better reliability and consistency for locomotor skills. Differences between these two findings may be due to the static versus dynamic presentation of the motor skills. The DSPMC allows children to see a full execution of continuous skills (i.e., motor tasks with no distinct beginning or ending) such as locomotor skills. We suggest that young children might find it challenging to understand their own locomotor abilities.[29] There is preliminary evidence that supports that performing a motor skill might influence how children perceive their own abilities[30]; therefore, while performing a skill before a

perceived motor competence assessment might increase understanding of the skill, it may interfere with measuring true "perceived competence". Additional work is needed to understand how performing motor skills prior to perceived motor competence assessments may influence children's self-perceptions, particularly for locomotor skills.

The present study examined the construct validity of the DSPMC in two ways. First, we examined how the DSPMC related to two other established measures of perceived motor competence: PSPCSA and PMSC. Results demonstrate a positive relationship among all three perceived competence assessments. However, the strength of the relationship varied across assessment types. The two assessments that included static pictures (i.e., PMSC and all subscales of the PSPCSA) were moderately related (r = 0.42 - 0.56), but the strength of the relationship between the assessment with digital clips (i.e., DSPMC) and either assessment with static pictures (i.e., PMSC and all subscales of the PSPCSA) were low (r = 0.25 - 0.39). Interestingly, there was no relationship between the object control subscales of the DSPMC and PMSC. While it is unclear why no relationship was present between the object control subscales on these two assessments, it is possible that young children may be able to report their actual ball skill performances using the DSPMC more accurately but are unable to categorize these performances as skilled versus unskilled. This explanation is supported because children's actual and perceived object control skills were correlated for the DSPMC but not the PMSC. Therefore, children understood how their actual object control skill performances related to the digital performances on the DSPMC but were not able to accurately report their ball skills when using a static measure of perceived motor competence.

Construct validity was examined by relating children's actual motor skills (i.e., TGMD score) to their perceived competence (i.e., PMSC, DSPMC, PSPCSA). The correlational analyses employed do not allow for causal inferences. Nonetheless, the repeated pattern of significance indicates a positive relationship between children's perceptions and their actual motor skills, supporting prior evidence indicating that children may perceive their motor abilities to some degree. The strength of the relationships between perceived and actual motor competence presented in this study is similar to the strength of these relationships in meta-analytic data.[4] Interestingly, this research found differences in the relationship between actual motor skills and perceived motor competence across the three assessments suggesting that

perceived motor competence assessments relate to actual motor skills differently. These findings are not surprising as young children may not be able to assess their abilities accurately, so weak positive correlations are expected.[5] Overall, the consistent pattern of low to moderate correlations between children's DSPMC scores and actual motor skill scores reported here align with literature on how perceived and actual motor competence relate at this age[4] and supports the content validity of the DSPMC.

Further, the correlations reported here partially align with previous work on the relationship between perceived and actual motor skill competence.[20,23] Robinson (2011) examined the relationship between actual and perceived motor skills as measured by the physical subscale of the PSPCSA in a sample of preschoolers from families of low socioeconomic status.[20] This study found that the PSPCSA average scale score was moderately correlated with both total (r = 0.48), locomotor (r = 0.43), and object control skills (r = 0.44) in young children. Other work found that kindergarteners' (M_{age} = 5.75 yrs) perceived physical competence as measured by the PSPCSA significantly correlated with their locomotor and object control skills (r_{range} = 0.26 - 0.33).[23] The strength of the correlations in the present study (r_{range} = 0.23 - 0.39) aligns with the correlation values from Crane et al.[23] but are slightly less than those reported by Robinson.[20] Both Robinson[21] and Crane et al.[23] found a significant relationship between the PSPCSA and object control skills. Still, the current investigation found that neither the PSPCSA nor the object control subscale for the PMSC related to children's actual object control skills. In contrast, the object control subscale for the DSPMC did relate to actual object control skills. This finding suggests that having a full dynamic presentation of skill performances might influence how children categorize their own abilities to propel or manipulate objects through space. It is possible that children may gravitate towards always picking the 'good' performance when given verbal prompts because they are unable to visually see the skill being executed or performed with a static picture. In other words, a young child who is a novice with motor skills and movement might not understand the movement patterns and may select what they interpret as the more socially desirable, or 'good', performance. A similar phenomenon may be occurring with the DSPMC whereby children are trying to select the more socially desired performance. However, based on the significant correlations between actual object control skills and perceptions of object control skills as assessed with the DSPMC may suggest that children can recognize and categorize their movement patterns more accurately when provided a

demonstration of the skill being executed with no verbal prompts that include descriptors of performance (e.g., "good"). While the construction of these instruments to include a skilled and a non-skilled performance is strategic as young children lack the reading ability and have not yet fully developed the concept of "personness",[5] more research is needed to evaluate why children select the performance they do and to potentially explore if these selections are made on social desirability versus accuracy or response.

One of the unexpected findings from the present investigation was the differences in scores between the DSPMC and the PMSC. Children's overall scores of perceived motor competence were different even though these two measures include identical skills. Scores were lower on the DSPMC compared to the PMSC for both the locomotor (DSPMC = 2.85 versus PMSC = 3.32) and object control skills (DSPMC = 2.68 versus PMSC = 3.18) subscale. The differences in these scores may explain why the object control subscale was not related between the two assessments and why the DSPMC was the only assessment related to actual object control skills. Nonetheless, the question remains *why were children's perceived motor competence scores lower on the DSPMC than on the PMSC?* One key difference between these two assessments is the presentation of skills. The PMSC provides children with a verbal description (e.g., "good" and "not so good") when introducing the two static pictures. In contrast, the DSPMC provides children with video information and does not supply children with any verbal descriptions regarding the quality of skill completion. This approach may allow children to perceive discrete skills such as object control skills more accurately, as discussed above. Still, it may not have as large of an effect on continuous skills like most locomotor skills. More work is needed to examine how differences in presentation (i.e., verbal instructions/prompt and visual information) affect children's perceived competence compared to children's perceived competence related to continuous and discrete skills on the DSPMC. In addition to differences in verbal prompts, the DSPMC and PMSC use different formats to present the data: electronically on a tablet versus hardcopy booklet. It is unclear how these two different presentation styles may have affected children's motivation or understanding of skill execution. Future work is needed to elucidate how presentation format may influence children's motivation to complete assessments, especially as the PMSC has recently been released in an app-based format.[31] More work is needed to compare how children's self-perceptions differ between this format of the PMSC and the DSPMC.

The advancement made in studying perceived motor competence would not be where it is without the work of researchers pushing the field forward and designing new and innovative assessments.[14,15,31-33] These perceived competence assessments now align with a common assessment of motor competence (i.e., Test of Gross Motor Development[16]), assess sport competence, and measure perceived motor competence in adolescence[33] and childhood.[31-32] Each new assessment has strengths and limitations. Concerns have been raised regarding the adequacy of DSPMC for measuring perceived motor competence in children based on (1) using an adult female model and (2) the verbal instruction "*which one moves like you"*.[31] We recognize these concerns; however, even with the current model and verbal instructions, the DSPMC has acceptable psychometric properties in school-aged children[17] and preschoolers (current study). These data support the DSPMC as a valid and reliable measure, and future research should continue to examine the psychometrics of this measure in a variety of populations. We also believe that using digital skill demonstrations, while unique, is appropriate. Research supports that digital skill demonstrations are effective and appropriate for providing skill demonstrations during the Test of Gross Motor Development[16,34] and teaching motor skills.[35,36] Therefore, this type of modeling appears to be an acceptable and good approach for providing children with skill demonstrations. The unique aspect of the digital presentation is another innovative contribution to the ongoing work in perceived competence measures.

4.1 Strengths and Limitations

The present study has several limitations that are important to consider. Due to the test-retest protocol and the similarities between the DSPMC and the PMSC, it was not feasible for children to complete all assessments on the same day. Researchers tried to control an ordering effect by reverse ordering the DSPMC, so the assessment was not presented in the same order twice and left time between administering the DSPMC and the PMSC. However, it is possible an ordering effect remained. Further, testing was completed in three university-sponsored preschool centers, and it is unclear how these results would generalize to other populations; therefore, future research is needed to examine the reliability and validity of this metric in different populations. This study and instrument have meaningful contributions to the literature on perceived motor competence even within these limitations.

This study also included several strengths. The sample used was racially diverse and larger samples than previous samples for both the DSPMC[17] and PMSC.[14] The reliability and validity of the DSPMC was assessed with two established measures of perceived competence; PSPCSA and PMSC. Lastly, construct validity was determined in two ways: (a) examining how the DSPMC related to two other measures of perceived motor competence, and (b) examining how the DSPMC related to actual motor skill competence.[22] To the best of our knowledge, this was the first time that three measures of perceived competence were used to examine the relationship between perceived and actual motor skill competence in young children. Lastly, the DSPMC is a potentially distributable assessment that could be easily used by researchers and non-experts alike as this assessment could be automated and requires no live demonstrations of skill performances. Future research is needed to determine non-experts' comfort and abilities to administer and interpret the findings from this assessment.

4.2 Perspective

This study determined the reliability and validity of the DSPMC in preschoolers. Results revealed the DSPMC is a reliable and valid measure of perceived motor competence in this population. The DSPMC had strong test-retest reliability, acceptable internal consistency, and good content validity with current other measures in the field. These results support the use of the DSPMC to measure perceived motor competence in preschool populations, but future work should continue to evaluate the psychometrics of this assessment in different populations and contexts.

References

1. Babic MJ, Morgan PJ, Plotnikoff RC, et al. Physical activity and physical self-concept in youth: systematic review and meta-analysis. *Sport Med.* 2014;44(11):1589-1601.
2. Visser EL, Mazzoli E, Hinkley T, et al. Are children with higher self-reported wellbeing and perceived motor competence more physically active? A longitudinal study. *Med Sci Sports Exerc.* 2011;13: 6–11.
3. Robinson LE, Stodden DF, Barnett LM, et al. Motor competence and its effect on positive developmental trajectories of health. *Sports Med.* 2015;45(9):1273-1284.

4. De Meester A, Barnett LM, Brian A, et al. The relationship between actual and perceived motor competence in children, adolescents and young adults: a systematic review and meta-analysis. *Sports Med.* 2020:1-49.
5. Harter S, Pike R. The pictorial scale of perceived competence and social acceptance for young children. *Child Dev.* 1984;55(6):1969-1982.
6. Nicholls JG. The development of the concepts of effort and ability, perceptions of own attainment, and the understanding that difficult tasks require more ability. *Child Dev.* 1978;49: 800–814.
7. Nicholls JG, Miller A. The differentiation of the concepts of difficulty and ability. *Child Dev.* 1983;54: 951–959.
8. Stodden DF, Goodway JD, Langendorfer SJ, et al. A developmental perspective on the role of motor skill competence in physical activity: an emergent relationship. *Quest.* 2008;60(2):290-306.
9. Estevan I, Bardid F, Utesch T, Menescardi C, Barnett LM, Castillo I. Examining early adolescents' motivation for physical education: associations with actual and perceived motor competence. *Phys Educ Sport Pedag.* 2020:1–16.
10. Ensrud-Skraastad OK, Haga M. Associations between motor competence, physical self-perception and autonomous motivation for physical activity in children. *Sports.* 2020;8:120.
11. Barnett LM, Morgan PJ, van Beurden E, Beard JR. Perceived sports competence mediates the relationship between childhood motor skill proficiency and adolescent physical activity and fitness: a longitudinal assessment. *Int J Behav Nutr Phys. Act* 2008;5(1):40.
12. Visser EL, Mazzoli E, Hinkley T, Lander NJ, Utesch T, Barnett LM. Are children with higher self-reported wellbeing and perceived motor competence more physically active? a longitudinal study. *Med Sci Sports Exerc.* 2011;13:6–11.
13. Palmer KK, Nunu MA, Scott-Andrews KQ, Robinson LE. Perceived physical competence predicts gains in children's locomotor but not ball skills across an intervention. *Int J Environ Res Public Health*. 2021; 18(11):5990.

14. Barnett LM, Ridgers ND, Zask A, Salmon J. Face validity and reliability of a pictorial instrument for assessing fundamental movement skill perceived competence in young children. *J Sci Med Sport.* 2015;18(1):98-102.
15. Barnett LM, Vazou S, Abbott G, et al. (2016). Construct validity of the pictorial scale of Perceived Movement Skill Competence. *Psychol Sport Exerc.* 2016;22:294-302.
16. Ulrich, D. *TGMD 2–Test of gross motor development examiner's manual*. Austin TX: Pro-Ed; 2000.
17. Robinson LE, Palmer KK. Development of a digital-based instrument to assess perceived motor competence in children: face validity, test-retest reliability, and internal consistency. *Sports.* 2017;5(3):48.
18. Goodway JD, Rudisill ME. Perceived physical competence and actual motor skill competence of African American preschool children. *Adapt Phys Activ Q.* 1997;14(4):314-326.
19. Logan S, Robinson L, Webster EK, Barber L. Exploring preschoolers' engagement and perceived physical competence in an autonomy-based object control skill intervention: a preliminary study. *Eur Phy Educ Rev.* 2013;19(3):302-314.
20. Robinson LE. The relationship between perceived physical competence and fundamental motor skills in preschool children. *Child Care Health Dev.* 2011;37(4):589-596.
21. Robinson LE, Rudisill ME, Goodway JD. Instructional climates in preschool children who are at-risk. Part II: Perceived physical competence. *Res Q Exerc Sport.* 2009;80(3):543-551.
22. Mokkink LB, Terwee CB, Patrick DL, et al. The COSMIN study reached international consensus on taxonomy, terminology, and definitions of measurement properties for health-related patient-reported outcomes. *J Clin Epidemiol.* 2010;63(7):737-745.
23. Crane JR, Naylor PJ, Cook R, Temple VA. Do perceptions of competence mediate the relationship between fundamental motor skill proficiency and physical activity levels of children in kindergarten? *J Phys Act Health.* 2015;12(7):954-961.
24. Marx RG, Menezes A, Horovitz L, Jones EC, Warren RF. A comparison of two time intervals for test–retest reliability of health status instruments. *J Clin Epidemiol.* 2003;56(8):730–735.

25. Rousson V, Gasser T, Seifert B. Assessing intrarater, interrater and test-retest reliability of continuous measurements. *Stat Med.* 2002;2:3431–3446.

26. Sattler JM, Theye F. Procedural, situational, and interpersonal variables in individual intelligence testing. *Psychol Bull.* 1967;*68*:347–360.

27. Sim J, Wright C. *Research in Health Care: Concepts, Designs and Methods*. Nelson Thornes; 2000.

28. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J Chiropr Med.* 2016;15(2):155-163.

29. Liong GH, Ridgers ND, Barnett LM. Associations between skill perceptions and young children's actual fundamental movement skills. *Percept Mot Skills.* 2015;120(2):591-603.

30. Rudisill ME, Wadsworth DD, Irwin JM, Hastie PA, Johnson JL, Bridges CE. Measuring perceptions of competence in young children: the influence of performing and observing one's performance on perceived competence scores. *J Sport Exerc Psychol.* 2016;*38*:S137-S138

31. Barnett LM, Makin O. An app to assess young children's perceptions of movement competence. *J Mot Learn Dev.* 2018;6(s2):s252-s263.

32. Dreiskaemper D, Utesch T, Tietjens M. The Perceived Motor Competence Questionnaire in Childhood (PMC-C). *J Mot Learn Dev.* 2018;6(2);264-280.

33. McGrane B, Belton S, Powell D, Woods CB, Issartel J. Physical self-confidence levels of adolescents: scale reliability and validity. *J Sci Med Sport.* 2016;19(7):563-567.

34. Robinson LE, Palmer KK, Irwin JM, et al. The use of multimedia demonstration on the test of gross motor development–second edition: performance and participant preference. *J Mot Learn Dev.* 2015;3(2):110-122.

35. Szeszulski J, Lorenzo E, O'Conner T, et al. Exploring correlates of preschool-aged children's locomotor skills: individual and parent demographics and home environment. *Percept Mot Skills.* 2021;128(2):649-671.

36. O'Loughlin J, Chróinín DN, O'Grady D. Digital video: the impact on children's learning experiences in primary physical education. *Eur Phys Ed Review*. 2013;19(2):165-182.

Table 1. Internal consistency and test-rest reliability of the DSPMC in preschoolers

		Initial test					Retest				
		Range	M (SD)	α	ω		Range	M (SD)	α	ω	ICC
All skills (N=12)	All (*N*=117)	20-48	3.00 (.57)	.78	.75	All (*N*=115)	23-48	2.94 (.55)	.75	.76	.84 (.76-.89)
	Boys (n=59)	20-48	3.02 (.58)	.80	.71	Boys (n=57)	23-48	2.99 (.54)	.73	.68	.87 (.77-.92)
	Girls (n=58)	21-48	2.97 (.55)	.75	.78	Girls (n=58)	23-48	2.90 (.56)	.77	.81	.80 (.66-.88)
Locomotor skills (*n*=6)	All (*N*=117)	9-24	3.03 (.63)	.66	.62	All (*N*=116)	9-24	2.86 (.59)	.58	.60	.77 (.66-.84)
	Boys (n=59)	10-24	3.05 (.65)	.69	.57	Boys (n=58)	9-24	2.94 (.56)	.61	.50	.80 (.66-.88)
	Girls (n=58)	9-24	3.01 (.63)	.63	.65	Girls (n=58)	13-24	2.78 (.61)	.55	.68	.74 (.55-.85)
Object Control skills (*n*=6)	All (*N*=117)	8-24	2.95 (.58)	.53	.55	All (*N*=115)	9-24	3.02 (.59)	.54	.57	.72 (.60-.81)
	Boys (n=59)	8-24	2.99 (.62)	.60	.54	Boys (n=57)	9-24	3.04 (.62)	.44	.44	.70 (.50-.83)
	Girls (n=58)	11-24	2.93 (.54)	.44	.58	Girls (n=58)	9-24	3.01 (.58)	.60	.79	.74 (.56-.85)

	1	2	3	4	5	6	7
1. PSPCSA	1						
2. PSPMC-Total	.55***	1					
3. PSPMC- Locomotor	.42***	.89***	1				

Table 2. Range and average scale score for each perceived motor competence assessment.

		Total		**Locomotor**		**OC**	
	n	Range	M_{skill} (SD)	Range	M_{skill} (SD)	Range	M_{skill} (SD)
PSPCSA	86	8 - 24	3.12 (.62)	-	-	-	-
PMSC	80	17 - 48	3.25 (.53)	10 - 24	3.32 (.56)	6 - 24	3.18 (.62)
DSPMC	85	23 - 43	2.77 (.42)	9 - 24	2.85 (.54)	9 - 22	2.68 (.42)

Note. PSPCSA does not have separate subscales for Locomotor and Object Control.

Table 3. Correlation values among three perceived motor skill measures.

4. PSPMC- Object Control	.56***	.91***	.63***	1			
5. DSPMC- Total	.32**	.37**	.35**	.32**	1		
6. DSPMC- Locomotor	.31**	.39***	.36**	.34**	.90***	1	
7. DPSMC- Object Control	.25*	.26*	.25*	.21	.83***	.51***	1

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

Table 4. Correlations between actual motor skills and perceived competence.

Perceived Motor Competence	TGMD		
	Total	Locomotor	Object Control
PSPCSA	.25*	.23*	.19
PSPMC-Total	.28*	.30**	.16
PSPMC- Locomotor	.26*	.33**	.10
PSPMC- Object Control	.24*	.23*	.18
DSPMC- Total	.38***	.29**	.36**
DSPMC- Locomotor	.36**	.24*	.39***
DPSMC- Object Control	.29**	.27*	.23*

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

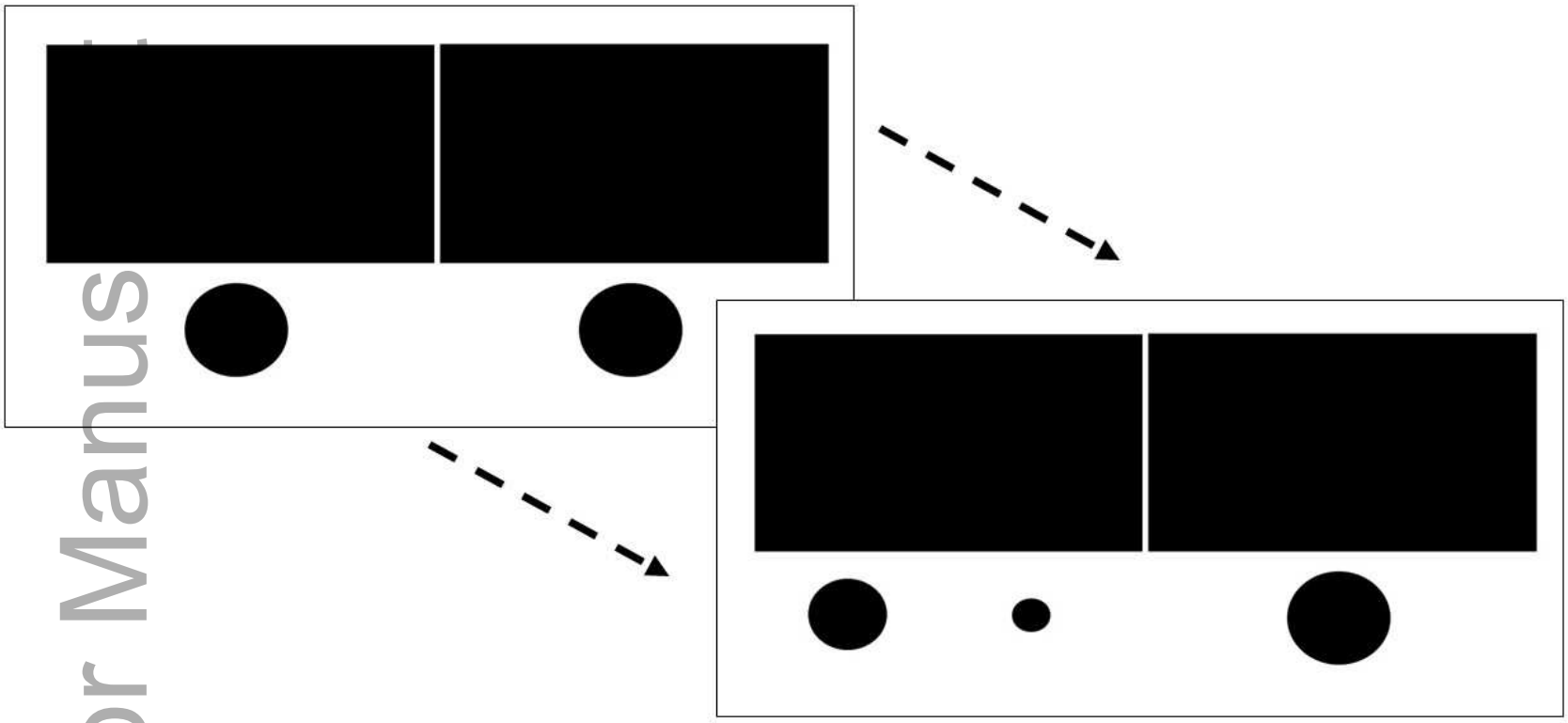

Figure 1. Example of presentation of DSPMC on a tablet.