

## **Assessing the Fidelity of Administering the Körperkoordinationstest für Kinder (KTK) in a U.S. Physical Education Setting: A Pilot Study**

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### **ABSTRACT**

Child injuries resulting from falls have risen in the United States (U.S.) over the past 10 years. Many falls are associated with motor coordination (MC) deficiencies. The Körperkoordinationstest für Kinder (KTK) is a standardized, norm-referenced MC measure used abroad, but is needed in the U.S. if delivered with fidelity. **Purpose:** The purpose of this study was to determine if physical educators could set-up, administer, and score the KTK subtests with 5th grade students using a Fidelity Checklist. **Methods:** This cross-sectional pilot study involved four physical educators from two elementary schools (School 1 N=32; School 2 N=28) who were trained on setting-up, administering, and scoring the four subtests (walking backwards on a balance beam (WB), lateral jump (LJ), sideways step (SS), and single leg hop (SH)) with fidelity. **Results:** Fidelity Checklist results showed the physical educators scored 100% on set-up, 95% on administration, and 96% on subtest scoring. The four subtests' internal consistencies were WB: 0.88; SH: 0.93; SS: 0.96; LJ: 0.94 which were comparable to the international studies. **Conclusion:** Findings suggest that the KTK assessment may be more suitable for use in larger U.S.-based studies to evaluate MC deficiencies in children, with the broader aim of informing fall prevention efforts.

*Keywords:* Postural balance, Children, Limb movements, Assessment, Motor Coordination

## **1. INTRODUCTION**

For the past ten years, falls have been the leading cause of non-fatal injuries for those under 15 years old (CDC, 2019). Approximately 2.2 million children a year under the age of 15 are admitted and treated at hospital emergency rooms due to unintentional fall injuries (WHO, 2021). Furthermore, these unintentional falls can cause complex injuries such as traumatic brain injuries, spinal cord injuries, and fractures in the lower extremities, which can exacerbate future fall injuries (Blosser & DePompei, 2019). Although each unintentional fall is complex and has its own etiology of occurrence, the majority of falls are due to deficiencies in motor coordination (MC) and balance capabilities which are intrinsically linked (McCrum et al., 2022). MC enables the precise and efficient use of multi-limb movements to achieve and maintain balance, whether static (still) or dynamic (moving). The cerebellum, a brain region, is crucial for this process, integrating sensory information from the eyes and inner ear (vestibular system) to make constant adjustments to muscle activity, ensuring postural stability, which is critical to overcome fall-related injuries (Campbell et al., 2022; Shim et al., 2019).

When given opportunities throughout the day to be active, especially outdoors, children learn to move kinesthetically. This means they can perceive the movement of a limb and its direction while engaging in single or combined motor tasks like walking, running, jumping, dodging, and climbing (Dankiw et al., 2020; Shim et al., 2019). These skills are foundational for proper fall and injury prevention (Dankiw et al., 2020; Lee et al., 2020). Yet, many U.S. children have limited opportunities to develop MC which aids in achieving and maintaining balance.

Presently, the school setting has become a major contributor of minimal movement experiences due to high-stakes testing pressures and increased classroom seat time taking up the majority of a seven-hour school day (Bai et al., 2016; Rhea, 2021). Since schools are limiting the child's ability to move kinesthetically throughout the day and fall related injuries are on the rise, it would be highly beneficial to assess MC and balance in children for developmental reasons.

Physical educators are trained to assess children's fitness and motor skill proficiencies, but have not been as focused on assessing MC and balance in children, since limited assessment tools exist in the U.S. presently (Campbell-Pierre & Rhea, 2023). One specific tool,

the *Körperkoordinationstest für Kinder* (KTK), developed in Germany, is one of the few valid assessment tools available for identifying gross MC deficiencies related to postural balance in children between the ages of 5-14 years (Giuriato et al., 2021). The KTK had been used extensively in other countries such as England, Germany, Brazil, and Finland (Giuriato et al., 2021). Researchers from these countries have repeatedly found the tool to be a valid and reliable MC assessment in physical education settings (Bardid et al., 2015; Ceyhan & Sogut, 2021; Vandorpe et al., 2011).

Due to the critical rise in sedentary lifestyles and physical inactivity percentages reported in U.S. children presently (CDC, 2022), it is important for physical educators to examine MC and balance proficiency levels in the schools. Since assessment tools are not readily available in the U.S. to assess these variables specifically, Campbell-Pierre and Rhea (2023) designed a U.S. feasibility study using the KTK in a physical education setting and deemed the KTK to be feasible with 8-10-year-old children. This was accomplished through 1) interpreting the scoring protocol and procedures into English from German; 2) determining the time to assess each skill in a U.S. physical education setting; and 3) determining equipment availability and cost to run the four KTK subtests. As this battery of tests only examined feasibility in the U.S., psychometrics and fidelity needed to be established next (Iivonen et al., 2016).

Therefore, the purpose of this study was to determine if physical educators could reliably and accurately set-up, administer, and score the KTK subtests with 5<sup>th</sup> grade students using a Fidelity Checklist in two very different U.S. elementary school physical education settings.

## **2. METHODS**

### **2.1 Participants**

#### ***Physical Educator Profile***

For this pilot study, four physical educators from two elementary schools were trained to set up the equipment, identify the skills needed to do the tasks and score the children with fidelity when implementing the tasks. Each school had one male and one female physical educator per class. All four teachers had 5-15 years of experience teaching physical education in an elementary school setting and had previously administered other assessments yearly in their physical education classes.

#### ***School Descriptives***

Two North Central Texas schools were included in the study. School 1 was a private school with three 15-minute unstructured, outdoor recess breaks daily and physical education 45-minutes daily. School 2 was a public school with two 15-minute unstructured outdoor recess breaks daily and physical education 50 minutes twice a week.

**Children Demographics Performing the KTK Assessments**

An initial convenience sample of 74, 10-year-old boys and girls, (5<sup>th</sup> grade), had parent consent and assented to complete the KTK assessments during a scheduled physical education class. The inclusion criteria were 5<sup>th</sup> grade 10-year-old boys and girls and full use of their whole body to complete each KTK subtest. The exclusion criteria were injuries preventing a child from executing a required body movement or a child’s verbal refusal to participate at any time during the data collection process. Each child who met the inclusion criteria above was evaluated on all four KTK subtests. Fourteen children did not complete one or more subtests because of injury or refusal to participate, leaving a total sample of 60. Table 1 provides the number and percentage of children who completed the KTK analyses by school and sex.

**Table 1**

*Participants by Group and Sex*

	<b>School 1</b>	<b>School 2</b>
<b>Male</b>	<b>19 (59.5%)</b>	<b>18 (64.5%)</b>
<b>Female</b>	<b>13 (40.5%)</b>	<b>10 (35.5%)</b>

**2.2 Measures**

***Körperkoordinationstest für Kinder (KTK; Kiphard & Schilling, 1974; 2007)***

This assessment tool has shown acceptable construct validity using intercorrelations between the four subtests which varied from 0.60 (WB/LJ) to 0.81 (SH/SS) and a test-retest reliability score of 0.97 on the KTK in countries outside of the U.S. (Moreira et al., 2019; Vandorpe et al., 2011). Each subtest item reflected internal consistency as well (WB: 0.80; SH: 0.96; SS: 0.84 and LJ: 0.95) (Giuriato et al., 2021). The four KTK subtest descriptions are listed below.

### ***Subtest 1: Walking Backwards on Balance Beam (WB)***

The WB subtest measures balance, rhythm, and strength. All three of these physical skill components determine the child's ability to move vertically and maintain postural stability while walking backwards on three different widths of balance beams (6.0 cm, 4.5 cm & 3.0 cm widths, 5 cm height). A child is given three attempts to reach a maximum of 24 steps per balance beam (8 per attempt), which equates to 72 maximum steps (24 x 3 balance beam steps) for this subtest.

### **Subtest 2: Lateral Jump (LJ)**

The LJ subtest measures speed, laterality, rhythm, and agility. All four of these physical components determine the child's ability to move laterally and maintain postural stability. A child jumps laterally as many times as possible over a wooden obstacle (25 x 25 x 5.7 cm) for 15 seconds. Two attempts are required. The number of jumps over two attempts is summed for the total score.

### **Subtest 3: Sideways Step (SS)**

The SS subtest measures speed, laterality, rhythm, and balance. All four of these components determine the child's ability to move laterally and maintain postural stability. This subtest assesses how well children move sideways on a wooden platform (25 x 25 x 5.7 cm) using a repetitive crossover motion for 20 seconds. The child transfers one of the plates to the other side of the plate they are standing on, steps onto the next plate, and repeats this process to accumulate as many transfers as possible in the 20 second time limit. A plate transfer counts as one point and stepping onto the next plate counts as one point. The total points are counted from both maneuvers, then summed from both attempts for the total score.

### **Subtest 4: Single Leg Hop (SH)**

The SH subtest measures balance, strength, and rhythm. All three of these physical skill components determine the child's ability to move vertically and maintain postural stability while performing a single leg hop over a foam obstacle (60 cm x 20 cm x 5 cm) with an increasing height of 5 cm per successful hop to 60 cm. Each leg is assessed separately with the same procedures. The children are given three attempts to perform a successful hop over each foam obstacle. A score is given to reflect the number of attempts it took the child to complete a successful jump per leg (1<sup>st</sup> attempt = 3 pts, 2<sup>nd</sup> attempt = 2 pts, and 3<sup>rd</sup> attempt = 1 pt.). A maximum of 36 points per leg can be achieved if they hop successfully over

every obstacle height on the first attempt. The total points from each leg are added together for a range of 36-72 points depending on how many attempts it takes to complete the task.

**KTK Scoresheet**

The KTK scoresheet was transcribed from German into English from the original KTK standardized handbook (Kiphard & Schilling, 1974; 2007). The score sheet is replicable and easy to document. A sample is shown in Figure 1.

**Figure 1**

*Scoresheet Sample - Balance Beam (WB)*

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KTK Score Sheet

Name: \_\_\_\_\_ Sex: \_\_\_\_\_

Grade: \_\_\_\_\_ School: \_\_\_\_\_

DOB: \_\_\_\_\_

Balance Beams (WB)

- Calculate the number of backward steps the participant takes.
- The first step from the platform does not count towards the eight steps. This is known as the plantar step so participants can find balance before walking backwards on the balance beam.
- Each step after the plantar step is counted (heel to heel) up to eight steps. If the child loses balance prior to eight steps, then the number achieved is documented.
- Add up the scores from all three attempts for a total score.

Total

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**Fidelity Checklist**

The Fidelity Checklist was created for this study to validate and monitor the evaluation process of the four KTK subtests consistently across physical education teachers from each school. The fidelity checklist consists of 72 total items divided into three key categories: Subtest Set-Up (8 items), Subtest Administration (22 items), and Subtest Scoring (42 items).

The setup category listed all equipment materials needed and how they should be set up to ensure safety and accuracy during the evaluation process. Figure 2 shows the WB subtest setup requirements as an example of how all four subtests were set up.

**Figure 2**

*WB Set Up Requirements*

	<b>Yes</b>	<b>No</b>
1. Does the WB subtest have all equipment needed to administer the assessment? <ul style="list-style-type: none"> <li>• Yellow Balance Beam</li> <li>• Red Balance Beam</li> <li>• Green Balance Beam</li> <li>• Balance Beam Platforms (1 per balance beam)</li> <li>• Clip Board</li> <li>• Pen or Pencil</li> </ul>		
2. Is the subtest set up correctly for evaluation? <ul style="list-style-type: none"> <li>• Balance Beam must be set up from largest width to smallest width.</li> <li>• Set up each balance beam at least 3 feet away from the next balance beam.                          Ex. Yellow balance Beam (6.0 cm) 3 ft away from Red Balance Beam (4.5 cm) then another 3 ft away from Green Balance Beam (3.0)</li> </ul>		

The subtest administration section focuses on how well the teacher administers each subtest following the scoring guidelines. Figure 3 shows the WB subtest administration section requirements as an example of the administration process used for each subtest.

**Figure 3**

*WB Subtest Administration Requirements*

	<b>Yes</b>	<b>No</b>
(1) Did the evaluator provide a clear space of at least 3 feet for the child to move appropriately before beginning the evaluation of this subtest?		

(2) Were the non-active children standing in a single file line at least 4 feet away from the evaluation area so the active child is not distracted during the evaluation of this subtest?

(3) Did each child get a chance to participate in the balance beam subtest in the same order each time?

(4) Did each child start at the opposite end of where the wooden platform was located so they have a chance to walk up the balance beam forward before participating in the backwards steps?

(5) Did each child hand off their score sheet to the evaluator when it was their turn to do the subtest?

(6) Were the children told the scripted instructions prior to beginning the subtest?

The subtest scoring section focuses on how well the teacher executes the scoring of the subtests to produce a valid raw score for overall performance. Figure 4 shows the WB subtest section requirements as an example of scoring the four subtests.

**Figure 4**

*WB Scoring Requirements*

	<b>Yes</b>	<b>No</b>
(1) Did each child begin with the yellow balance beam (The widest at 6.0 cm)?		
(2) Did the child reset at the wooden platform if they fell off the balance beam to begin the next attempt?		
(3) Did the evaluator wait until the 2 <sup>nd</sup> backward step to begin counting the eight steps possible? i.e., "The first Step, " <b>plantar step</b> ", is not supposed to count toward the child's total maximum backward steps		
(4) Did the evaluator count the number of steps completed walking backwards (from 0 to a maximum 8) and record on the score sheet?		

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(5) Did the child have 3 attempts on the yellow balance beam?

(6) Did the child move to the red balance beam (4.5 cm) after completing the three trials at the yellow beam? Then move to the green balance beam (3.0 cm) after completing the three trials at the red balance beam.

\*Steps 1-5 presented above should be repeated for each balance beam (yellow, red, and green) during the administration of this subtest.

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### **2.3 Procedures**

Following approval from the University Institutional Review Board, elementary school administrators approved the data collection and physical educators approved of their role in assessing the students with the KTK subtests during the physical education class.

KTK adherence training was scheduled at both schools to address the KTK implementation for each physical educator involved in data collection. The training addressed each required objective from each of the subtest sections. This training took approximately 90 minutes at each school. During the training, physical educators were required to move through all fidelity checklist steps with the researcher. This included setting up the equipment, administering the subtests, and scoring the subtests. Once the physical educators demonstrated they could perform each part successfully, dates were scheduled for each school to implement the subtests in their 5<sup>th</sup> grade classes. The fidelity checklist was left with each physical educator for review prior to assessing the children.

On the assessment day, the primary researcher arrived in the school gym 30 minutes prior to the first class start time to do the fidelity check on the equipment set up. Next, the fidelity checklist was used to determine if subtest directions and the scoring rubric were followed correctly. If at any point the teacher omitted a directive or step in the process, the researcher would stop the teacher, have them correct the issue, and re-evaluate the child.

The two physical educators (evaluators) at each school began their class with instructions for KTK participation, followed by a brief demonstration of each subtest. Then the class was split in half, approximately 14–16 children in each group, and dispersed to their assigned subtest station. Each evaluator then gave each child a pencil and a score

sheet attached to a clipboard to complete the demographic section. Once completed, the evaluators at each station had their children line up in a single file line and maintain possession of their clipboard/scoresheet until called to participate. Once a child completed the task, the next child was called up, handed their scoresheet to the evaluator, and performed the task. The evaluator administered the subtest, recorded their scores, and handed the score sheet back to the child to return to the end of the line. Once the two groups completed the subtests, the groups switched stations to complete the other subtest. At the end of each class, the evaluators would mark where they were with the subtest if not completed, instruct the children to return their score sheets and prepare to leave for their next class. It took three 45-minute class periods at both schools to complete the four subtests.

### **3. RESULTS**

#### ***Subtest Set-Up Requirements***

The results revealed the physical education teachers at both schools scored 100% on the fidelity checklist for setting up each of the four KTK subtests. Each subtest included two setup items for a total of eight items in that section. Equipment for each subtest was accounted for during the evaluation process and set up correctly in the gym with the proper amount of space between each subtest station.

#### ***Subtest Administration Requirements***

The results from each subtest administration section showed 95% accuracy from both schools. The WB subtest has six items, LJ has five items, SS has five items, and SH has six items resulting in 22 total items. The physical educators at both schools scored 21/22 items correctly from administering the four subtests. Item #4 of the SH subtest section was the only item missed. This item requires the child to start behind the mat, hop onto the mat, then over the foam pad, then two more hops with balance with the same foot all the way through. The physical educators were allowing the children to start on the mat instead of behind the mat. The researcher corrected each evaluator and had them start again so the scoring was not impacted.

#### ***Subtest Scoring Requirements***

The subtest number of scoring items varied: the WB subtest had 15 items, LJ had six items, SS had eight items, and SH had 14 items resulting in 43 total items. School 1 physical educators scored 42 of 43 items (97%)

accurately across the four subtests. School 2 physical educators scored 41/43 items (95%) accurately across the four subtests. Item #3 from the WB subtest section was missed by all four evaluators. This item required the first backward step called the plantar step to be a practice step which evaluators incorrectly attempted to count. School 2 physical educators also missed item #5 on the SS subtest. This item required physical educators to give a 10-second break between the two SS attempts. For both errors, the researcher corrected each evaluator and had them start again so the scoring was not impacted.

### **Reliability**

Reliability was calculated to assure the subtest scores had internal consistency using Cronbach's  $\alpha$ . The findings showed similar alpha coefficients as the other countries (WB:0.80; SH: 0.84; SS:0.96; LJ:0.95) (Giuriato et al., 2021). The alpha coefficients of the four subtests for this study were WB: 0.88; SH: 0.93; SS: 0.96; and LJ: 0.94.

## **4. DISCUSSION**

This study sought to determine if physical educators could reliably and accurately set-up, administer, and score the KTK subtests with 5<sup>th</sup> grade students using a Fidelity Checklist in two very different U.S. elementary school physical education settings. Findings suggest that the KTK can be used in the U.S. with reliability and accuracy.

Physical educators at both schools consistently set up the equipment at each subtest station correctly prior to administration. They were also able to administer the KTK protocol and procedures for each subtest during their scheduled P.E. classes, with both schools scoring 95% accuracy (one minor error). Lastly, the physical educators demonstrated they could score each subtest correctly, with 1-2 minor errors.

However, the three errors made with either administration or scoring steps need to be addressed for KTK use in the future since they will impact the execution and scoring if not performed accurately. One recommendation, across all subtests, but especially for the SH subtest, is to practice the fidelity steps 2-3 times during the initial training session and then re-testing the teachers one week later for accuracy before evaluating the subtest with the children. Each teacher only practiced one time and it was assumed they would be ready. Adding subtest demonstration videos could give a much stronger visual for each evaluator and help with the three details missed as well. Finally, adding some prompting cues to the fidelity checklist to assist evaluators during the evaluation period would promote accuracy. For

example, adding a note at the bottom of the score sheet of each fidelity checklist subtest giving scoring tips to reference quickly on the day of evaluation may help (Figure 1). Since this was a pilot study, assessing U.S. physical educators again with the fidelity checklist after including the improved training steps should create a highly accurate assessment tool.

The physical educators were able to show comparable high reliability to KTK study results from other countries on the four subtests (Giuriato et al., 2021). The high reliability may be due to the recently published protocol and procedures (Campbell-Pierre & Rhea, 2023), the newly developed fidelity checklist, training prior to the KTK, and maybe even the physical educator's prior experiences assessing children in their physical education settings.

A recommendation for future researchers, based on previous researchers' time constraints using the KTK, is to use at least two sets of KTK equipment, especially for the SH and WB subtests (Campbell-Pierre & Rhea, 2023). The evaluators in this study used two sets for each of these subtests with no incidence. They not only found the time per student was cut in half compared to the previous U.S. feasibility study, but the children had much less downtime between attempts (Campbell-Pierre & Rhea, 2023). Finally, the ease and adaptability of the KTK setup, administration, and scoring to U.S. physical education settings enhances feasibility and long-term use in schools. The physical educators stated on numerous occasions that the setup, administration, and scoring were very manageable and easy to assess. These findings may support sustained implementation for teacher use and fidelity over time in order to determine MC deficiencies in 3<sup>rd</sup> through 5<sup>th</sup> grade children.

## **5. CONCLUSIONS**

In conclusion, this pilot study shows promise for the KTK assessment to determine MC and postural balance abilities in U.S. children. The translated scoresheet, fidelity checklist, protocol, and procedures as developed and documented in this study reflect similar results to previous studies, as well as demonstrating comparable internal consistency (Giuriato et al., 2021).

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### **6.2 Conflict of Interest (de-identify in blinded manuscript)**

The authors declare no conflicts of interest.

### **6.3 Contribution of Authors (exclude in blinded manuscript)**

DJR: conceptualization, supervision, methodology, validation, formal analysis, writing—original draft, writing—review and editing, visualization; DCP: conceptualization, methodology, formal analysis, writing—original draft, visualization; YZ: methodology, supervision, formal analysis, writing—original draft, writing—review and editing; GWK: writing—review and editing.

## **7. REFERENCES**

- Bai, Y., Chen, S., Laurson, K. R., Kim, Y., Saint-Maurice, P. F. & Welk, G. J. (2016). The associations of youth physical activity and screen time with fatness and fitness: The 2012 NHANES National Youth Fitness Survey. *PLOS ONE*, *11*(1), e0148038.  
<https://doi.org/10.1371/journal.pone.0148038>
- Bardid, F., Rudd, J. R., Lenoir, M., Polman, R. & Barnett, L. M. (2015). Cross-cultural comparison of motor competence in children from Australia and Belgium. *Frontiers in Psychology*, *6*, 964.  
<https://doi.org/10.3389/fpsyg.2015.00964>
- Barnett, L. M., Lai, S. K., Veldman, S. L., Hardy, L. L., Cliff, D. P., Morgan, P. J., ... & Okely, A. D. (2016). Correlates of gross motor competence in children and adolescents: A systematic review and meta-analysis. *Sports Medicine*, *46*, 1663-1688.  
<https://doi.org/10.1007/s40279-016-0495-z>
- Bertapelli F., Pitetti K., Miller R.A., Jaeger A., Loovis M., do Amaral-Junior W.D., de Barros-Filho M.M. & Guerra-Junior G. (2020). Comparing

- motor competence of sex- and age-matched youth with intellectual disability from Brazil and the United States. *Adaptive Physical Activity*, 37(4):423-440. <https://doi.org/10.1123/apaq.2019-0185>. PMID: 32963125.
- Blosser, J. & DePompei, R. (2019). *Pediatric traumatic brain injury: Proactive Intervention*. Plural Publishing.
- Campbell-Pierre, D., Rhea, D. & Baker, K. (2022). What is the relationship between outdoor play breaks & no play breaks on postural balance? A Systematic Review. *Journal of Health and Physical Literacy*, 1(2), 122-134. <https://johpl.org/index.php/johpl/article/view/10>
- Campbell-Pierre, D., & Rhea, D. J. (2023). The feasibility of using the Körperkoordinationstest für Kinder (KTK) in a US elementary physical education setting to assess gross motor skills specific to postural balance. *Frontiers in Sports and Active Living*, 5, 1133379. <https://doi.org/10.3389/fspor.2023.1133379>
- Centers for Disease Control and Prevention. *Overweight and obesity*. (2022, October). U.S. Department of Health and Human Services. <https://www.cdc.gov/obesity/childhood/index.html>
- Centers for Disease Control and Prevention. *Children safety and injury prevention recommendations*. (2019) Overview. Atlanta, GA: U.S. Department of Health and Human Services. <https://www.cdc.gov/early-care/safety/index.html>
- Ceyhan, A., & Söğüt, M. (2021). Association Between Motor Competence and Body Mass Index in Children Aged 10-13. *Turkiye Klinikleri Journal of Sports Sciences*. <https://doi.org/10.5336/sportsci.2020-76449>
- Dankiw, K. A., Tsiros, M. D., Baldock, K. L., & Kumar, S. (2020). The impacts of unstructured nature play on health in early childhood development: A systematic review. *PLOS ONE*, 15(2): e0229006. <https://doi.org/10.1371/journal.pone.0229006>
- Dirik, H. B., & Söğüt, M. (2021). Age-related Differences in Motor Coordination Among Young Soccer Players. *Journal of Sports Sciences*, 13(1). <https://doi.org/10.5336/sportsci.2020-76232>
- Farbo, D., Maler, L. C., & Rhea, D. J. (2020). The preliminary effects of a multi-recess school intervention: Using accelerometers to measure physical activity patterns in elementary children. *International Journal of Environmental Research and Public Health*, 17(23), 8919. <https://doi.org/10.3390/ijerph17238919>
- Farbo, D. J., & Rhea, D. J. (2022). The effects of a yearlong recess intervention on body fat shifts in elementary-aged children. *International Journal of Child Health and Nutrition*, 11(2): 60-71. <https://doi.org/10.6000/1929-4247.2022.11.02.1>
- Freitas, D. L., Lausen, B., Maia, J. A., Lefevre, J., Gouveia, É. R., Thomis, M., ... & Malina, R. M. (2015). Skeletal maturation, fundamental motor skills and motor coordination in children 7–10 years. *Journal of Sports*

- Sciences*, 33(9): 924-934.  
<https://doi.org/10.1080/02640414.2014.977935>
- Gilbert, A. S., Schmidt, L., Beck, A., Kepper, M. M., Mazzucca, S., & Eyler, A. (2021). Associations of physical activity and sedentary behaviors with child mental well-being during the COVID-19 pandemic. *BMC Public Health*, 21(1), 1-12. <https://doi.org/10.1186/s12889-021-11805-6>
- Giuriato, M., Biino, V., Bellafiore, M., Battaglia, G., Palma, A., Baldari, C., ... & Lanza, M. (2021). Gross motor coordination: We have a problem! A study with the körperkoordinations test für kinder in youth (6–13 years). *Frontiers in Pediatrics*, 1404.  
<https://doi.org/10.3389/fped.2021.785990>
- Iivonen, S., Sääkslahti, A., & Laukkanen, A. (2016). A review of studies using the Körperkoordinationstest für Kinder (KTK). *European Journal of Adapted Physical Activity*, 8. <https://doi.org/10.5507/euj.2015.006>
- Kiphard, E.J. & Schilling, F. (1974). *Körperkoordinationstest für Kinder*. Belz Test, Weinham.
- Kiphard, E.J. & Schilling, F. (2007). *Körperkoordinationstest für Kinder 2, überarbeitete und ergänzte Aufgabe*. Beltz Test, Weinham.
- Laukkanen, A., Bardid, F., Lenoir, M., Lopes, V. P., Vasankari, T., Husu, P., & Sääkslahti, A. (2020). Comparison of motor competence in children aged 6-9 years across northern, central, and southern European regions. *Scandinavian Journal of Medicine & Science in Sports*, 30(2), 349-360. <https://doi.org/10.1111/sms.13578>
- Lee, J., Zhang, T., Chu, T. L., & Gu, X. (2020). Effects of a need-supportive motor skill intervention on children's motor skill competence and physical activity. *Children*, 7(3), 21.  
<https://doi.org/10.3390/children7030021>
- Lee, R. L. T., Lane, S., Brown, G., Leung, C., Kwok, S. W. H., & Chan, S. W. C. (2020). Systematic review of the impact of unstructured play interventions to improve young children's physical, social, and emotional wellbeing. *Nursing & Health Sciences*, 22(2), 184-196.  
<https://doi.org/10.1111/nhs.12732>
- Lund, E., Brimo, D., Rhea, D., & Rivchun, A. (2017). The effect of multiple recesses on listening effort: A preliminary study. *Journal of Pediatric, Educational, & Rehabilitative Audiology*, 23, 1-7.
- McCrum, C., Bhatt, T. S., Gerards, M. H., Karamanidis, K., Rogers, M. W., Lord, S. R., & Okubo, Y. (2022). Perturbation-based balance training: Principles, mechanisms and implementation in clinical practice. *Frontiers in Sports and Active Living*, 4, 1015394.  
<https://doi.org/10.3389/fspor.2022.1015394>
- Moreira, J. P. A., Lopes, M. C., Miranda-Júnior, M. V., Valentini, N. C., Lage, G. M., & Albuquerque, M. R. (2019). Körperkoordinationstest Für Kinder (KTK) for Brazilian children and adolescents: Factor analysis,

- invariance and factor score. *Frontiers in Psychology*, *10*, 02524. <https://doi.org/10.3389/fpsyg.2019.02524>
- Parrish, A. M., Chong, K. H., Moriarty, A. L., Batterham, M., & Ridgers, N. D. (2020). Interventions to change school recess activity levels in children and adolescents: a systematic review and meta-analysis. *Sports Medicine*, *50*(12), 2145-2173. <https://doi.org/10.1007/s40279-020-01347-z>
- Pienaar AE, Monyeki MA, Coetzee D, Gerber B, du Plessis W, du Plessis AM, Kruger R. (2022). Age and sex differences in the state and relationships between process and product assessments of fundamental-motor skills in five to eight-year-olds: The ExAMIN Youth SA study. *International Journal of Environmental Research and Public Health*, *19*(15), 9565. <https://doi.org/10.3390/ijerph19159565>
- Rhea, D. J. (2021). Let the kids play: The impact of chaos on academic success. *Journal of Kinesiology & Wellness*, *10*, 98-105.
- Rhea, D. J., Kirby, K., Cheek, D., Zhang, Y., & Webb, G. K. (2025). The impact of recess on chronic stress levels in elementary school children. *Children*, *12*(7), 865. <https://doi.org/10.3390/children12070865>
- Rhea, D.J., Rivchun, A., & Clark, L. (2018). *LiiNK Project®: Case Study*. Chapter. Instructional Leadership in the Content Areas: Case Studies for Curriculum and Instruction. Routledge/University Council for Educational Administration.
- Rhea, D. J., & Rivchun, A. P. (2018). The LiiNK Project®: Effects of multiple recesses and character curriculum on classroom behaviors and listening skills in grades K–2 children. *Frontiers in Education*, *3*, 9. <https://doi.org/10.3389/feduc.2018.00009>
- Shim, A., & Rose-Woodward, J. (2019). Dynamic balance drills to promote skill acquisition and prevent injuries in children. *Strategies*, *32*(3), 3-11. <https://doi.org/10.1080/08924562.2019.1585703>
- Tsuda, E., Goodway, J. D., Famelia, R., & Brian, A. (2020). Relationship between fundamental motor skill competence, perceived physical competence and free-play physical activity in children. *Research Quarterly for Exercise and Sport*, *91*(1), 55-63. <https://doi.org/10.1080/02701367.2019.1646851>
- Vandorpe, B., Vandendriessche, J., Lefèvre, J., Pion, J., Vaeyens, R., Matthys, S., ... & Lenoir, M. (2011). The Körperkoordinationstest für kinder: Reference values and suitability for 6–12-year-old children in Flanders. *Scandinavian Journal of Medicine & Science in Sports*, *21*(3), 378-388. <https://doi.org/10.1111/j.1600-0838.2009.01067.x>
- Williams, A. (2021). *Purposeful play: The impact of increased unstructured play on fitness levels in school-aged children* (Order No. 28965058). Available from Dissertations & Theses @ Texas Christian University; ProQuest Dissertations & Theses Global. (2622966380). Retrieved

from

[http://library.tcu.edu/PURL/EZproxy\\_link.asp?/login?url=https://www.proquest.com/dissertations-theses/purposeful-play-impact-increased-unstructured-on/docview/2622966380/se-2](http://library.tcu.edu/PURL/EZproxy_link.asp?/login?url=https://www.proquest.com/dissertations-theses/purposeful-play-impact-increased-unstructured-on/docview/2622966380/se-2)

World Health Organization. (2021, April). Falls <https://www.who.int/news-room/fact-sheets/detail/falls>