Development and validation of the Kradot Kop Test: a culturally grounded field-based assessment of restricted lower-limb power–endurance in Thai children aged 10–12 years

Desarrollo y validación del Kradot Kop Test: una evaluación de campo con base cultural de la potencia-resistencia restringida de las extremidades inferiores en niños tailandeses de 10 a 12 años

Authors

Tachapon Tongterm [1]
Khanittha Chimphali [1]
Thanyaporn Pengseesang [1]
Methawut Pongtanu [2]
Sarocha Namboonlue [2]
Kittamook La-bantao [2]

[1] Sisaket Rajabhat University (Thailand)
[2] Ubon Ratchathani Rajabhat University (Thailand)

Corresponding author:
Tachapon Tongterm
tachapon.t@sskru.ac.th

Received: 23-12-25
Accepted: 06-01-25

How to cite in APA

Tongterm, T., Chimphali, K., Pengseesang, T., Pongtanu, M., Namboonlue, S., & La-bantao, K. (2026). Development and validation of the Kradot Kop Test: a culturally grounded field-based assessment of restricted lower-limb power–endurance in Thai children aged 10–12 years. *Retos, 76*, 168-181. https://doi.org/10.47197/retos.v76.118433

Abstract

Introduction: School fitness assessment often relies on standardized tasks emphasizing precision over cultural relevance and engagement, especially where traditional movements are central to children's experience.
Objective: This study developed and validated the Kradot Kop Test (KKT) as a culturally grounded, field-based assessment of lower-limb power–endurance in Thai children aged 10–12.
Methodology: A sequential R&D design was used. Validity and reliability were established via expert review, inter-rater/test–retest procedures, and correlations with established strength/power indicators. Field testing evaluated feasibility and performance across age and sex.
Results: The KKT showed excellent inter-rater and good intra-rater reliability. Concurrent validity showed moderate associations with standardized measures, supporting construct specificity. High feasibility and acceptance were reported, with clear age- and sex-related differentiation.
Discussion: Findings support adapting culturally embedded movements into valid assessments.
Conclusions: The KKT integrates Thai heritage with sport science, offering a sustainable, contextually meaningful physical education tool.

Keywords

Kradot Kop Test; restricted lower-limb power–endurance; traditional games; field-based assessment; Thai children.

Resumen

Introducción: La evaluación física escolar suele emplear tareas estandarizadas que priorizan la precisión sobre la relevancia cultural, especialmente donde las prácticas motrices tradicionales son fundamentales para los niños.
Objetivo: Este estudio desarrolló y validó el Kradot Kop Test (KKT) como evaluación de campo, culturalmente fundamentada, de la potencia–resistencia del tren inferior en niños tailandeses (10-12 años).
Metodología: Se utilizó un diseño de I+D secuencial. La validez y fiabilidad se establecieron mediante revisión de expertos, procedimientos interevaluador/test–retest y correlaciones con indicadores de fuerza/potencia. Las pruebas de campo evaluaron la factibilidad y el rendimiento por edad y sexo.
Resultados: El KKT mostró excelente fiabilidad interevaluador y buena intraevaluador. La validez concurrente reveló asociaciones moderadas con medidas estandarizadas, respaldando la especificidad del constructo. Se reportó alta factibilidad y aceptación, con clara diferenciación por edad y sexo.
Discusión: Los hallazgos respaldan la adaptación de movimientos culturales en evaluaciones válidas.
Conclusiones: El KKT integra el patrimonio tailandés con la ciencia del deporte, ofreciendo una herramienta sostenible y significativa para la educación física.

Palabras clave

Kradot Kop Test; potencia–resistencia restringida de los miembros inferiores; juegos tradicionales; evaluación de campo; niños tailandeses.

Introduction

Children's physical competence plays a central role in shaping health, learning capacity, and participation trajectories across the life course. In late childhood, particularly between the ages of 10 and 12 years, fundamental movement skills undergo a critical phase of consolidation, during which motor proficiency and habitual physical activity patterns begin to stabilize and demonstrate increasingly predictive associations with later health outcomes (Barnett et al., 2016; Stodden et al., 2008). During this stage, physical fitness is closely associated not only with motor competence and sport participation, but also with broader developmental domains, including cognitive functioning and psychosocial well-being (Cattuzzo et al., 2016; Lubans et al., 2016). Despite the recognized importance of this stage, global surveillance data consistently indicate that a substantial proportion of school-aged youth fail to achieve recommended levels of daily physical activity. This persistent pattern highlights a structural challenge within contemporary childhood environments, reinforcing the need for developmentally appropriate, engaging, and contextually relevant strategies to support physical competence within institutional settings such as schools (World Health Organization, 2020).

Physical education (PE) represents a primary institutional platform for supporting motor development during childhood; however, its educational effectiveness is strongly influenced by the assessment tools used to guide instruction, monitor progress, and foster student engagement (Dudley et al., 2011; Marques et al., 2021). Commonly applied school-based fitness assessments, including the Standing Broad Jump and leg dynamometry, provide reliable indicators of lower-limb power, yet their emphasis on isolated performance outcomes, repetitive execution, and equipment-dependent procedures may limit student engagement and practical feasibility in everyday educational contexts (Azlan et al., 2021). In response to these limitations, international scholarship has increasingly emphasized the pedagogical and developmental value of integrating traditional and indigenous games into PE, recognizing their capacity to promote physical literacy, meaningful participation, and cultural relevance (Abdullah & Amri, 2018). Traditional games typically involve rhythmical and repetitive movement patterns that engage whole-body coordination and require adaptive control within culturally meaningful activity structures, while also fostering emotional and social engagement during physical activity participation (Lavega-Burgués et al., 2021; Sinulingga et al., 2026). Within the Thai context, previous studies have demonstrated that such movement traditions can be systematically refined into reliable field-based assessment tools, including the 2-Minute Kra Dot Yang Test and the 4-Corner Elastic Jumping Test, illustrating a viable pathway for aligning cultural heritage with empirical sport science and educational assessment while maintaining ecological relevance within school-based PE practice (Tongterm et al., 2023; Tongterm et al., 2025).

From a motor development and assessment perspective, the present study is grounded in the concept of restricted lower-limb power–endurance, defined here as the capacity to repeatedly generate forceful lower-limb propulsion under biomechanical constraints that limit compensatory strategies and external momentum. This construct is conceptually distinct from explosive power, which emphasizes maximal force output in a single or brief action; from muscular endurance, which typically reflects submaximal force production over prolonged durations; and from anaerobic capacity, which primarily refers to metabolic energy supply during high-intensity activity. Instead, restricted lower-limb power–endurance reflects an integrative motor construct that combines repeated force production, postural control, proprioceptive regulation, and fatigue management within constrained movement conditions.

Among Thai traditional activities, Kradot Kop, commonly referred to as the "frog jump," presents a distinctive movement pattern characterized by repeated squatting and forward jumping performed while maintaining a continuous ankle hold. From a biomechanical perspective, this constrained posture limits arm-swing contribution and reduces elastic recoil, thereby isolating lower-limb muscle function and emphasizing repeated force production under restricted conditions. Accordingly, Kradot Kop provides an ecologically valid movement context through which restricted lower-limb power–endurance can be functionally observed and measured, rather than inferred indirectly through isolated strength or power tests. Such characteristics suggest that Kradot Kop reflects a hybrid performance construct that is not adequately captured by conventional fitness assessments focused solely on maximal strength or explosive power.

Grounded in this rationale, the present study aimed to develop and validate the Kradot Kop Test (KKT) as a culturally grounded, field-based assessment for Thai children aged 10 to 12 years. Specifically, the study sought to: 1) develop the KKT through expert validation and protocol refinement; 2) examine its reliability and concurrent validity against standardized indicators of lower-limb performance; 3) evaluate its pedagogical feasibility within school-based PE contexts; and 4) analyze age- and sex-related performance characteristics using large-scale field data. By addressing these objectives, the study contributes an assessment model that integrates traditional movement heritage with contemporary sport science, offering a contextually relevant and educationally meaningful approach to youth fitness evaluation.

Method

This study was designed to systematically develop and validate a culturally grounded, field-based fitness assessment derived from a traditional Thai movement. A structured methodological framework was employed to ensure scientific rigor, procedural transparency, and applicability within school-based physical education contexts. The methodological process integrated expert validation, standardized protocol development, psychometric evaluation, and large-scale field testing to examine the reliability, validity, feasibility, and performance characteristics of the KKT.

Study design

This study employed a sequential, multiphase Research and Development (R&D) design integrated with a cross-sectional validation approach. The overall process was structured into three interrelated phases: 1) content identification and expert validation of traditional activities; 2) standardized protocol development and psychometric evaluation; and 3) large-scale field-based testing to examine feasibility and performance distribution. All research procedures were conducted in accordance with the ethical standards of the Research Ethics Review Committee of Sisaket Rajabhat University and were approved under Protocol No. 010/2564.

Participants

Participants were recruited using a multi-stage sampling strategy across the different phases of the R&D process. The total sample consisted of 660 individuals, distributed as follows:

- Development phase: Five experts in sports science and physical education with experience in youth fitness assessment participated in content validity evaluation.

- Psychometric phase: Sixty school-aged children (30 boys, 30 girls; aged aged 10.0–12.9 years) were recruited to assess reliability, concurrent validity, and feasibility.

- Field evaluation phase: A large school-based sample of 600 Thai children (300 boys and 300 girls), stratified equally by age (10, 11, and 12 years; n = 100 per age per sex), participated in field-based performance analysis.

All child participants were free from musculoskeletal injury and medical conditions limiting physical activity. Written informed consent was obtained from parents or guardians, and verbal assent was obtained from the children prior to participation.

Development of the Kradot Kop Test

The development of the KKT followed a systematic and evidence-based process to ensure that the selected movement was culturally relevant, biomechanically appropriate, safe for school-aged children, and suitable for standardization as a field-based fitness assessment. This phase focused on identifying and refining a traditional Thai activity that could validly represent the construct of restricted lower-limb power–enduranceprior to formal protocol standardization and psychometric evaluation.

Selection and identification of traditional activities

The development process began with a systematic review of Thai traditional games emphasizing lower-limb movement patterns relevant to power and endurance. Based on criteria of cultural familiarity, safety, feasibility, and potential for standardization, three activities were shortlisted: Kradot Kop (frog jump), Ti Kai Khon (man-cockfight), and Wing Krasob (sack run).

Content validity was evaluated using the Index of Item–Objective Congruence (IOC) (Rovinelli & Hambleton, 1976). Five experts independently assessed each activity with respect to movement clarity, safety, consistency, and suitability for school-based assessment. Kradot Kop demonstrated the highest content validity (IOC = 1.00) and was selected as the foundational movement for test development, as its biomechanical characteristics aligned most closely with the construct of restricted lower-limb power–endurance.

Standardization of the Kradot Kop Test protocol

The selected activity was refined into a standardized assessment protocol, technically termed the 10-Meter Restricted Frog Jump, with the primary objective of minimizing extraneous movement contributions while maximizing procedural consistency across testing settings. The standardization process emphasized both biomechanical control and field-based feasibility to ensure reliable administration within regular school environments.

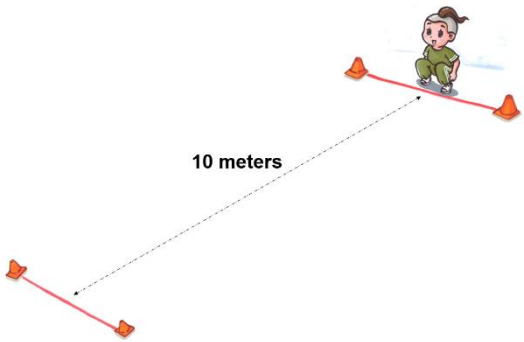
A key biomechanical constraint was imposed by requiring participants to maintain a continuous hold on both ankles throughout the test. This restriction effectively eliminated arm-swing momentum and reduced elastic recoil, thereby isolating force production to the lower-limb musculature and emphasizing repeated concentric and eccentric loading. From a squatting starting position, participants performed consecutive forward jumps over a fixed distance of 10 meters along a standardized testing lane (see Figure 1). Completion time, recorded in seconds using a digital stopwatch with 0.01-second precision, served as the primary performance outcome. All participants received standardized verbal instructions and a visual demonstration prior to testing (illustrated in Figure 2). One familiarization trial was provided to ensure task comprehension, followed by two recorded trials, with the best performance retained for analysis.

To enhance procedural transparency and facilitate replication, the equipment setup and standardized field layout are illustrated in Figure 1, including the testing area, start and finish markers, and measurement distance. The visual execution of the 10-meter restricted frog-jump technique is illustrated in Figure 2, highlighting body posture, the continuous ankle-hold constraint, and the sequential jumping mechanics required throughout the test. Together, these visual representations complement the written protocol and support clarity in both test implementation and future replication of the KKT.

Figure 1. Standardized field layout and equipment setup for the 10-meter Restricted Frog Jump (KKT).

Note: The figure illustrates the testing area, start and finish markers, measurement distance, and spatial configuration used to ensure procedural consistency during test administration.

Figure 2. Execution of the 10-meter restricted frog-jump technique in the KKT.



Note: The figure demonstrates body posture, continuous ankle-hold constraint, and sequential jumping mechanics required throughout the test to isolate restricted lower-limb power–endurance.

Reliability, validity, and feasibility procedures

Reliability: The reliability of the KKT was examined using both inter-rater and intra-rater approaches. Inter-rater reliability was assessed by two trained examiners who independently recorded completion times for the same testing trials, following identical procedural instructions. Intra-rater reliability was evaluated using a test–retest design with a seven-day interval, selected to balance measurement stability with the minimization of learning effects and short-term fatigue adaptation, while remaining feasible within the scheduling constraints of school-based physical education settings. This interval is consistent with common practice in field-based fitness reliability studies involving children. Reliability coefficients were interpreted according to established guidelines for intraclass correlation coefficients (Shrout & Fleiss, 1979).

Concurrent validity: Concurrent validity was examined by analyzing the relationships between KKT completion time and standardized fitness tests representing theoretically related constructs. Leg dynamometer strength (normalized to body mass) was used as an indicator of maximal isometric lower-limb strength, and the standing broad jump was used as an indicator of explosive lower-limb power, as both measures are widely established and routinely applied in youth fitness assessment. Pearson correlation coefficients were interpreted using commonly accepted behavioral science criteria (Hinkle et al., 2003). This approach allowed evaluation of whether the KKT captures a related yet distinct performance construct rather than duplicating existing measures.

Feasibility and pedagogical utility: Feasibility and pedagogical utility were assessed through a post-test questionnaire administered to participating students and physical education teachers. A five-point Likert scale was used to evaluate perceived enjoyment, clarity of instructions, safety, and ease of implementation within regular physical education class time (Vonglao, 2017). This procedure was designed to determine whether the KKT could be realistically administered in school settings without disrupting routine instructional activities.

Statistical analysis

All statistical analyses were conducted using SPSS for Windows (Version 26.0). Descriptive statistics were calculated and reported as means and standard deviations. Reliability was assessed using intraclass correlation coefficients (ICC) based on a two-way mixed-effects model with absolute agreement, while concurrent validity was examined using Pearson product–moment correlation coefficients. For large-scale field-based evaluation, KKT completion times were summarized by sex and age group using descriptive statistics and field-based reference percentiles (P10, P30, P50, P70, and P90). Sex-related differences were explored using independent-samples t-tests, and age-related differences were examined using one-way analysis of variance (ANOVA). Statistical significance was set at $p < .05$ for all analyses.

Results

The results are presented in accordance with the study objectives and follow a sequential research and development framework, encompassing the outcomes of test development, descriptive statistics, reliability and concurrent validity, feasibility, and field-based performance characteristics of the KKT.

Outcomes of test development

The development of the KKT was guided by a structured research and development process aimed at identifying a Thai traditional movement suitable for standardization as a field-based assessment of restricted lower-limb power–endurance. Three candidate activities, including Kradot Kop (frog jump), Ti Kai Khon (man-cockfight), and Wing Krasob (sack run), were evaluated by five experts in sports science and physical education using the Index of Item–Objective Congruence.

As summarized in Table 1, Kradot Kop demonstrated the highest content validity with an IOC value of 1.00. Although Ti Kai Khon and Wing Krasob met acceptable IOC thresholds, both activities exhibited practical limitations during preliminary evaluation, including unstable postural control and high movement variability, which limited their suitability for procedural standardization in school-based testing environments.

Subsequent pilot testing with youths aged ten to twelve years confirmed that Kradot Kop allowed consistent execution of repeated movements, high participant compliance, and clear rule-based control under school-based conditions. Based on these findings, Kradot Kop was refined into a standardized assessment protocol, formally termed the KKT, and operationally defined as a ten-meter restricted frog-jump test with completion time recorded in seconds as the primary performance outcome.

Table 1. Content validity evaluation of candidate Thai traditional activities using the Index of Item–Objective Congruence

Traditional Game (Thai name)	Description	IOC value	Decision	Expert Notes
Kradot Kop/Frog Jump (กระโดดกบ) 	Repeated frog-jump movement under restricted posture	0.80	Selected	Consistent movement, safe, easy to standardize
Ti Kai Khon/Man-Cockfight (ตีไก่คน) 	Dynamic balance and pushing movements	0.73	Rejected at pilot stage	High balance demand; moderate consistency
Wing Krasob/Sack Run (วิ่งกระสอบ) 	Jumping locomotion with external constraint	0.60	Excluded	High variability; difficult to standardize

Note: IOC values were evaluated by five experts in sports science and physical education. Kradot Kop was selected due to the highest content validity and superior procedural control under school-based conditions.

Descriptive statistics

Descriptive characteristics were examined using data from the psychometric validation sample consisting of sixty school-aged children, with equal representation of boys and girls and a balanced age distribution across ten, eleven, and twelve years. The mean age of participants was approximately eleven years (11.0 ± 0.8 years). Mean body mass and stature were within expected ranges for this age group (38.5 ± 7.9 kg and 145.2 ± 8.6 cm, respectively), reflecting typical growth patterns among school-aged youth. The mean body mass index indicated that most participants fell within the normal range (18.1 ± 2.9 kg/m^2), with limited representation of underweight or overweight classifications.

Resting heart rate values were consistent with normative expectations for children of this age (78.4 ± 6.7 beats per minute), suggesting the absence of abnormal cardiovascular conditions within the sample. Overall, the distribution of anthropometric and physiological characteristics supports the representativeness of the sample and confirms its suitability for evaluating the reliability and concurrent validity of a field-based assessment targeting restricted lower-limb power–endurance. Performance on the KKT demonstrated sufficient variability across participants, indicating appropriate score dispersion for subsequent psychometric analyses.

Reliability and concurrent validity

To establish the measurement quality of the KKT, analyses were conducted to examine score consistency and its associations with established fitness measures representing related but distinct lower-limb performance constructs.

Reliability

Reliability of the KKT was examined using intraclass correlation coefficients based on a two-way mixed-effects model with absolute agreement. The test demonstrated excellent inter-rater reliability and good intra-rater reliability, indicating a high degree of measurement consistency across raters and repeated testing occasions. Detailed reliability coefficients and confidence intervals are reported in Table 2.

Table 2. Inter-rater and intra-rater reliability of the KKT (n = 60)

Reliability type	ICC model	ICC	95% CI	Interpretation
Inter-rater reliability	ICC(3,k)	0.90	0.85–0.93	Excellent
Intra-rater reliability	ICC(3,1)	0.83	0.75–0.88	Good

Note: ICC values were calculated using a two-way mixed-effects model with absolute agreement.

Concurrent validity

Concurrent validity was examined by correlating KKT completion time with standardized fitness tests assessing isometric lower-limb strength, explosive power, and speed-related performance. As presented in Table 3, KKT completion time demonstrated a moderate negative correlation with leg dynamometer strength, a moderate negative correlation with standing broad jump distance, and a low positive correlation with ten-meter shuttle run time.

These correlation patterns align with theoretical expectations for time-based and non-time-based fitness measures. They indicate that while the KKT is associated with traditional indicators of muscular strength and explosive power, its performance outcomes are not redundant with any single standardized test.

Taken together, these distinct correlation patterns confirm that the KKT captures a hybrid construct of restricted lower-limb power-endurance, which is functionally different from pure explosive power, isolated muscular strength, or general speed-based agility.

Table 3. Correlation between KKT completion time and standardized fitness tests (n = 60)

Standardized test	Construct assessed	r	Relationship strength
Leg dynamometer (normalized)	Isometric lower-limb strength	− 0.65*	Moderate
Standing broad jump	Explosive power	− 0.50*	Moderate
10-m shuttle run	Speed / agility	0.30*	Low

Note: The KKT and the 10-m shuttle run are time-based assessments in which lower values indicate better performance, whereas higher values indicate better performance for distance-based and force-based tests. Negative correlations therefore reflect inverse performance directions between time-based and non-time-based measures.

Feasibility

Feasibility analysis revealed consistently high levels of satisfaction among both students and teachers following administration of the KKT. Student responses indicated that the test was perceived as highly enjoyable, engaging, and motivating, with the highest ratings observed for items related to enjoyment of the activity (M = 4.33, SD = 0.66) and perceived benefits gained from participation (M = 4.70, SD = 0.53). Students also reported that the test procedures were easy to understand (M = 4.27, SD = 0.69) and could be completed within an appropriate time frame (M = 4.10, SD = 0.66), suggesting that the restricted movement format did not create unnecessary complexity or fatigue. The overall student satisfaction score was high (M = 4.32, SD = 0.63), supporting the acceptability of the test from the learner perspective.

Teacher evaluations further confirmed the practical feasibility of the KKT in school settings. Teachers reported high satisfaction with the clarity of test procedures (M = 4.10, SD = 0.66), the availability of standardized guidelines and visual instructions (M = 4.23, SD = 0.74), and the ease of organizing test stations within limited space and time constraints (M = 4.10, SD = 0.80). Importantly, teachers rated the safety of the test for children aged ten to twelve years as high (M = 3.83, SD = 0.79), indicating that the restricted frog jump movement did not raise concerns regarding injury risk when properly supervised. The overall teacher satisfaction score (M = 4.01, SD = 0.74) reflects strong confidence in the test's usability and alignment with physical education class requirements.

Taken together, these findings demonstrate that the KKT is not only psychometrically sound but also highly feasible for routine implementation in school based physical education. High satisfaction across both student and teacher groups supports the classification of the test as an enjoyment based, time efficient, and safe field assessment of restricted lower limb power endurance, reinforcing its applicability in real world educational contexts.

Field-based performance characteristics

Field-based testing was conducted with a large school-based sample of six hundred students to examine the practical applicability and performance distribution of the KKT under authentic educational conditions. The sample consisted of three hundred boys and three hundred girls, evenly stratified across the ages of ten, eleven, and twelve years, resulting in one hundred participants per age group. Descriptive characteristics of the full sample indicated a heterogeneous yet representative school population with respect to age distribution, body mass, stature, and body mass index, supporting the suitability of the sample for large-scale field implementation.

Analysis of KKT performance revealed consistent sex- and age-related patterns. Boys demonstrated faster completion times than girls across all age groups, and performance improved progressively with increasing age in both sexes, indicating clear age-related differentiation in restricted lower-limb power–endurance. At the same time, wide performance ranges and relatively large standard deviations were observed within several subgroups. These distributional characteristics reflect natural variability in task execution under real school-based testing conditions, where performance may be influenced by differences in movement coordination, fatigue tolerance, task engagement, and occasional interruptions during test administration. Importantly, this variability does not indicate measurement error but rather reflects the ecological validity of the KKT when implemented in typical physical education settings.

A small number of extreme values, particularly unusually long completion times, were observed in some age–sex groups. These values are likely attributable to non-systematic factors commonly encountered in school-based field testing, such as temporary fatigue, brief interruptions during task execution, loss of balance requiring movement correction, or incomplete familiarization with the restricted movement pattern despite standardized instruction. Importantly, these extreme observations were retained in the

analysis to preserve ecological validity and reflect authentic performance conditions rather than controlled laboratory settings.

To support interpretation in educational and field-based contexts, KKT outcomes were summarized as performance distributions stratified by sex and age, as presented in Table 4. Mean completion times, variability, and observed ranges demonstrate substantial score dispersion within each subgroup, highlighting the test's capacity to discriminate performance levels across a general school population. The distributional characteristics of KKT performance are further illustrated in Figure 1, which presents boxplot visualizations of completion time by age and sex. The figure highlights median values, interquartile ranges, and observed outliers, providing a transparent representation of performance dispersion and feasibility at scale under authentic school-based conditions.

In addition to descriptive statistics and distributional visualization, field-based reference percentiles were calculated to facilitate practical interpretation of KKT performance in educational settings. As shown in Table 5, percentile values (P10, P30, P50, P70, and P90) were derived separately by age and sex to reflect relative performance levels within the present sample. These percentiles provide contextual benchmarks for identifying lower, average, and higher performance ranges under real school-based testing conditions and are intended to support educational use rather than normative classification.

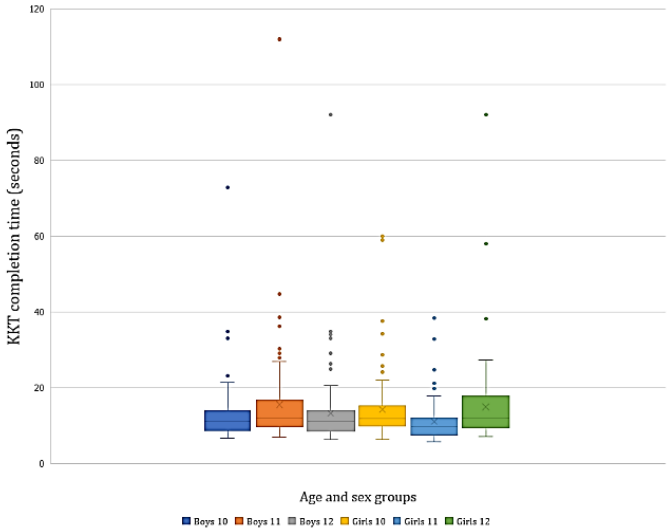
The performance data presented in this section are provided as contextual reference information to demonstrate discriminative capacity and feasibility of the KKT when applied at scale. They are not intended to establish national normative standards.

Table 4. Field-based performance distribution of the KKT by sex and age (n = 600)

Age (years)	Mean (s)	SD	Min	Max
Boys (n = 300)				
10	13.29	8.48	6.64	72.78
11	15.50	12.24	6.81	112.00
12	13.21	10.03	6.21	92.00
Total	14.00	10.38	6.21	112.00
Girls (n = 300)				
10	14.28	8.43	6.28	60.00
11	10.98	5.52	5.75	38.30
12	14.91	10.51	7.08	92.00
Total	13.39	8.56	5.75	92.00

Note: Lower values indicate better performance. Data are presented as field-based reference information to demonstrate feasibility and discriminative capacity and are not intended to establish national normative standards.

Figure 1. Distribution of KKT completion time by sex and age group (n = 600).



Note: Lower values indicate better performance. Boxes represent interquartile ranges, central lines indicate medians, and dots represent observed outliers. The figure illustrates natural performance dispersion and feasibility at scale under school-based testing conditions and is not intended to establish normative reference values.

Table 5. Field-based reference percentiles of KKT completion time by age and sex (n = 600)

Age (years)	Sex	P90 (Very Good)	P70 (Good)	P50 (Average)	P30 (Low)	P10 (Very Low)
10	Boys	≤ 7.17	≤ 7.78	≤ 8.58	≤ 14.11	≥ 14.12
	Girls	≤ 7.55	≤ 8.44	≤ 14.01	≤ 19.90	≥ 19.91
11	Boys	≤ 6.77	≤ 7.46	≤ 11.99	≤ 15.50	≥ 15.51
	Girls	≤ 7.01	≤ 7.85	≤ 13.90	≤ 19.88	≥ 19.89
12	Boys	≤ 6.05	≤ 6.85	≤ 10.49	≤ 14.28	≥ 14.29
	Girls	≤ 6.28	≤ 7.00	≤ 11.20	≤ 14.91	≥ 14.92

Note: KKT performance is measured in time (seconds), with lower values indicating better performance. These percentiles are provided as field-based reference indicators derived from the present sample and are intended to support educational interpretation. They are not intended to represent national normative standards.

Discussion

The empirical evidence generated in this study indicates that the KKT demonstrates sound psychometric quality and contextual relevance for assessing physical competence among school-aged children. Beyond establishing reliability and concurrent validity, the present findings allow clearer interpretation of the specific motor construct assessed by the test. In this regard, the concept of restricted lower-limb power–endurance provides a focused framework for understanding how biomechanical constraints and functional performance demands are integrated within a culturally grounded movement task, without reiterating broader contextual arguments already outlined in the Introduction.

Restricted lower-limb power–endurance as a distinct motor construct

The present findings indicate that the KKT captures a specific form of restricted lower-limb power–endurance derived from a culturally familiar movement pattern. Consistent with prior evidence on traditional and play-based activities, repetitive whole-body movements performed under meaningful constraints can stimulate neuromuscular coordination and sustained force production rather than isolated maximal output (Abdullah & Amri, 2018; Azlan et al., 2021). Rather than reframing traditional play as an abstract cultural value, the KKT operationalizes this movement logic into a measurable and reproducible performance construct grounded in authentic execution.

The constrained frog-jump configuration of the KKT aligns with developmental perspectives emphasizing the role of task constraints in shaping motor behavior and competence (Barnett et al., 2016). By eliminating arm swing and requiring continuous ankle holding, the task imposes heightened demands on proprioceptive awareness, joint stability, and internal motor regulation. These demands represent core components of physical literacy, particularly in tasks requiring sustained neuromuscular control under fatigue. Accordingly, the KKT reflects functional motor competence expressed through coordinated regulation under constraint, rather than isolated physical capacity.

Psychometric integrity and construct differentiation

The high inter-rater and intra-rater reliability observed in this study demonstrates that the KKT yields stable and reproducible outcomes when administered in authentic school-based settings. This finding is consistent with international methodological guidelines indicating that field-based assessments can achieve strong psychometric quality when standardized protocols are rigorously applied (Koo & Li, 2016; Shrout & Fleiss, 1979). Importantly, the concurrent validity pattern supports construct differentiation rather than redundancy. The moderate associations with leg dynamometer strength and standing broad jump performance, together with weak associations with shuttle run outcomes, indicate that the KKT is related to but distinct from conventional indicators of maximal strength, explosive power, or speed. This pattern reinforces the interpretation of restricted lower-limb power–endurance as a hybrid construct that integrates repeated force production with postural control, rather than duplicating established fitness measures (Marques et al., 2021).

Construct specificity beyond conventional balance assessments

While conventional balance assessments primarily emphasize static or controlled dynamic postural stability (Sember et al., 2020), the KKT requires functional stability under conditions of repeated high-intensity force production. Maintaining postural integrity while executing cyclical locomotor actions represents a more complex neuromuscular demand than isolated balance or strength tasks. This

distinction positions the KKT as an assessment of movement competence under realistic performance conditions commonly encountered in play and sport participation, extending beyond the scope of traditional balance assessments.

Educational relevance and ecological validity

From an educational perspective, the large-scale field implementation of the KKT supports its feasibility within routine physical education practice. The observed age- and sex-related performance differentiation is consistent with established developmental trajectories during late childhood (Miguel-Etayo et al., 2014). Specifically, sex differences are likely attributable to biological maturation and sexual dimorphism, during which boys typically demonstrate greater increases in fat-free mass and higher glycolytic enzyme activity, facilitating more robust repeated force production during cyclical jumping tasks such as the KKT (Marques et al., 2021). Importantly, this differentiation emerges under authentic school-based testing conditions. Rather than being interpreted as measurement noise, the observed performance dispersion reflects the heterogeneity inherent in real educational contexts, aligning with contemporary perspectives that emphasize ecological validity over laboratory-controlled uniformity (Cruz-León et al., 2025).

Cultural grounding and sustainable assessment practice

The integration of Kradot Kop into a standardized assessment framework illustrates how culturally familiar movement forms can be sustained through functional application rather than symbolic representation alone. International scholarship increasingly conceptualizes traditional games as living practices, in which cultural meaning is reproduced through embodied participation and pedagogical use rather than static preservation (Luchoro-Parrilla et al., 2021).

Within this framework, the KKT extends international approaches to culturally grounded assessment by embedding a locally meaningful movement pattern within a rigorously validated measurement structure. This integration supports educational models that position traditional games as functional tools for learning, assessment, and value transmission when systematically incorporated into contemporary practice (de Jesús et al., 2023; Munares et al., 2025). Accordingly, the KKT exemplifies a sustainable assessment approach that aligns cultural continuity with empirical accountability without overstating cultural claims.

Limitations and future research directions

Several limitations should be acknowledged. Concurrent validity was established using maximal strength and power indicators rather than endurance-specific physiological benchmarks. Future investigations should incorporate physiological measures, such as heart rate variability or post-test blood lactate concentration, to further substantiate the endurance-related properties of the KKT (Cruz-León et al., 2025; Galvani et al., 2024). In addition, the cross-sectional design and region-specific sampling limit broader generalizability.

Future research should explore longitudinal and multi-site applications to examine developmental sensitivity and transferability across diverse contexts. The potential integration of digital or hybrid assessment formats also warrants consideration as technology-assisted field testing becomes increasingly accessible in educational settings (Qiu et al., 2021; Klein et al., 2025).

Conclusions

The present study successfully developed and validated the KKT, technically defined as the 10-Meter Restricted Frog Jump, as a reliable, valid, and feasible field-based assessment for evaluating restricted lower-limb power–endurance among Thai children aged 10 to 12 years. Through a systematic research and development process, a culturally familiar traditional movement was rigorously refined into a standardized assessment protocol with explicit biomechanical constraints, demonstrating robust psychometric properties and clear construct differentiation from conventional indicators of lower-limb strength and explosive power. Importantly, the KKT was shown to capture a distinct hybrid performance construct characterized by repeated force production under movement restriction, thereby providing a complementary measure rather than duplicating existing fitness tests. High

satisfaction ratings from both students and physical education teachers further confirmed the test's safety, pedagogical utility, and ease of implementation within authentic school-based contexts. Moreover, large-scale field application revealed consistent age- and sex-related performance differentiation alongside natural performance variability, supporting the ecological validity and practical applicability of the KKT under real-world educational conditions. Collectively, these findings indicate that the KKT is ready for broader contextual application and continued experimental refinement, representing an innovative and sustainable assessment model that bridges Thai cultural heritage with empirical sport science while supporting physical literacy and inclusive physical education practices in Thailand.

Acknowledgements

The authors sincerely thank the parents and guardians of all participating students for providing informed consent and continued support throughout the study. The authors extend their appreciation to the physical education teachers and school administrators in Sisaket Province for their essential cooperation and assistance in facilitating field implementation. Special thanks are also due to the students whose active participation made this research possible. The authors further acknowledge the administrative support provided by the Research and Development Institute, Sisaket Rajabhat University. Responsibility for the study design, data collection, analysis, and interpretation of the findings rests solely with the authors.

Financing

This research was supported by funding from the Research and Development Institute (RDI), Sisaket Rajabhat University.

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Authors and translators' details:

Tachapon Tongterm	tachapon.t@sskru.ac.th	Author and Translator
Khanittha Chimphali	K.chimpalee@sskru.ac.th	Author
Thanyaporn Pengseesang	thanyaporn.w@sskru.ac.th	Author
Methawut Pongtanu	methawut.p@ubru.ac.th	Author
Sarocha Namboonlue	sarocha.n@ubru.ac.th	Author
Kittamook La-bantao	kittamook.l@ubru.ac.th	Author