

One test, many insights: Using motor skill correlations to streamline assessment in elementary physical education

MIRI SHACHAF¹, AYELET DUNSKY²

¹The Department of Physical Education at Givat Washington Academic College of Education, ISRAEL

²The School of Human Movement and Sport Sciences, The Levinsky-Wingate Academic College, Wingate Campus, ISRAEL

Published online: December 31, 2025

Accepted for publication: December 15, 2025

DOI:10.7752/jpes.2025.12274

Abstract

Problem Statement: Physical education teachers who frequently perform sport skills evaluations often encounter challenges such as limited equipment, inadequate facilities, and restricted time. **Purpose:** The current study aimed to assess possible correlations between: 60m run (60mR), 600m run (600mR), 4*10m run (Agility), running long jump (RLJ), standing long jump (SLJ), and throwing a ball (TaBall), to find possible ways to reduce the number of tests needed to be performed. **Approach:** Measurements were taken from 142 girls from 5th and 6th grade who participated in the study during regular physical education classes. The Pearson correlation coefficient was employed to evaluate the relationship between the variables. **Results:** The highest correlation was found between 60mR and Agility ($r = 0.80$), followed by high correlations between 60mR and RLJ ($r = -0.73$) and between RLJ and Agility ($r = -0.70$). Moderate correlations were found between SLJ and TaBall ($r = 0.41$), 600mR and HJ ($r = -0.44$), Agility and TaBall ($r = -0.45$), 60mR and TaBall ($r = -0.45$), HJ and Agility ($r = -0.48$), RLJ and TaBall ($r = 0.52$), 600mR and SLJ ($r = -0.52$), 600mR and RLJ ($r = -0.58$), 60mR and HJ ($r = -0.58$), 600mR and Agility ($r = 0.59$), RLJ and SLJ ($r = 0.61$), SLJ and Agility ($r = -0.62$), 60mR and 600mR ($r = 0.64$), HJ and SLJ ($r = 0.64$), HJ and RLJ ($r = 0.65$), and between 60mR and SLJ ($r = -0.66$). Weak correlations were found between HJ and TaBall ($r = 0.33$), and the lowest and non-significant correlations were found between 600mR and TaBall ($r = -0.17$, $p_{BH} = 0.06$). **Conclusions:** Based on the results, it is reasonable to suggest to physical education teachers who lack time or facilities that they assess only a few motor skills instead of wasting time on unnecessary assessments during valuable physical education lessons. For example, based on the high correlation between 60mR and the Agility test (4×10 m), we suggest performing only one of them. One possible approach is to ask students to choose their preferred assessment method.

Keywords: motor abilities, sport performance assessments, limited equipment, inadequate facilities

Introduction

Physical education teachers regularly conduct sport skills assessments throughout the academic year to evaluate student performance and identify top students who may represent the school in competitive events. Occasionally, when faced with constraints such as limited equipment, inadequate facilities, or restricted time, these teachers seek alternative ways to assess several different skills by either reducing the number of assessments or using predictive measures of future achievements. A possible solution to this challenge might be to consider that success in one skill could signal success in another, more easily measurable skill.

When assessing sport or motor skills, one should consider the fundamental components that comprise those skills, which are basic motor abilities. The development of motor abilities and motor skills in children has been the subject of extensive empirical investigation, underscoring its crucial role in the broader spectrum of child development (Cattuzzo et al., 2016; Lopes et al., 2021). It should be noted that similar but not entirely overlapping terms are sometimes used in the literature, such as Basic Motor Competencies (MCs), which refer to essential movement skills required for a broad range of activities (Novotná et al., 2025), and are defined as a broad term encompassing various aspects of human motor skills, including motor proficiency, fundamental motor skills, motor ability, and motor coordination (Logan et al., 2018). Conversely, motor abilities can be defined as inherent, enduring, and relatively stable traits that form the foundation for an individual's capacity to execute a diverse array of motor skills (Lee & Schmidt, 2025; Magill & Anderson, 2017; Goodway et al., 2021). These abilities encompass characteristics such as strength, balance, speed, coordination, agility, and reaction time, which collectively serve as the underpinnings for the acquisition and refinement of motor skills.

While it is widely recognized that all motor abilities can be enhanced to varying degrees through training and experiential engagement (Lopes et al., 2021), specific abilities are deemed more amenable to improvement than others. For instance, attributes such as strength, endurance, balance, and coordination demonstrate

substantial enhancement through targeted exercise and repetitive practice throughout the lifespan, particularly during the formative years. In contrast, attributes such as simple reaction time are often perceived as less malleable due to their strong neurological foundations (Guo et al., 2024).

Motor skills are fundamentally understood as the ability to execute complex neuromuscular actions through the effective coordination of sensory, cognitive, and motor systems, thereby facilitating purposeful movements. This skill set is developed exclusively through systematic practice and experiential learning, as indicated by Stodden et al. (2008). Motor skills serve as the foundational capability for engagement in various physical activities and are integral to daily functioning, as well as participation in sports and exercise. Activities such as running, jumping, and kicking exemplify these skills and are typically cultivated through extensive practice and experience (Liu et al., 2023; Payne & Isaacs, 2020), and are categorized as gross motor skills, which involve the execution of large movements of the arms, legs, and torso, thereby underscoring their significance in a range of physical endeavors (Li et al., 2025; Lee & Schmidt, 2025).

The relationship between motor abilities and motor skills can be understood through the dynamic systems theory, which provides a comprehensive framework and views motor development as the outcome of complex interactions among three subsystems:

1. The individual's abilities – including strength, flexibility, coordination, and neuromuscular control (Thelen, 2005).
2. The environment – external conditions such as the surfaces we walk or run on, or the presence of obstacles (Smith & Gasser, 2005).
3. The task – the specific action being performed, like walking, running, or catching a ball (Thelen, 2005).

According to dynamic systems theory, motor development is non-linear, meaning that it does not occur in a predictable, step-by-step process. Instead, it emerges from the reciprocal interaction between the person, the environment, and the task. These interactions influence and shape both motor abilities and motor skills over time. For instance, an individual with strong balance ability might easily learn to walk a tightrope. However, the skill itself is not determined solely by ability; it also depends on the practice dedicated to that task, the unique characteristics of the tightrope, and the surrounding environment (e.g., wind conditions). Therefore, motor abilities serve as rate limiters or facilitators for skill acquisition, affecting how quickly and efficiently new skills can be learned and refined (Button et al., 2021). Indeed, research consistently demonstrates that individuals with stronger fundamental motor abilities, such as coordination, balance, and agility, tend to acquire and execute a wider range of motor skills more efficiently (Magill & Anderson, 2017; Schmidt et al., 2018). For instance, a person with superior static and dynamic balance (an ability) may find it easier to master complex gymnastic routines or ice skating (skills). Nevertheless, the continuous practice of specific motor skills can also lead to an improvement in the underlying motor abilities, creating a reciprocal relationship between the two (Cleland-Donnelly et al., 2016; Magill & Anderson, 2017).

As motor abilities form the foundation for motor skills performance, there are motor skills that are dependent on a few common abilities. For example, the “standing long jump” (SLJ - a motor skill) requires explosive power and lower body strength (motor abilities), while the “running long jump” (a more complex skill) is based on explosive power and lower body strength but also requires speed and coordination.

The literature suggests that athletic performance in jumping and running events shows strong interrelationships based on power, speed, and coordination. For example, Hudgins et al. (2013) found some correlations between three “two-leg standing long jumps” (performed in immediate succession) and time running performance in events of varying distances (60, 100, 200, 800, 3,000, and 5,000 meters). However, the strength of the correlations, in general, was strongest to weakest, based on event distance, ranging from the shortest distance (60 m) to the longest distance (5,000 m). (Hudgins et al., 2013). Mishra & Rathore (2016) found a significant negative correlation between long jump performance and speed and agility; i.e., those with superior long jump performance were also faster and more agile. Loturco et al. (2021) found very large to nearly perfect negative correlations between SLJ and 100 m sprint times in elite sprinters, indicating that the higher the SLJ distance, the faster the sprint times (Loturco et al., 2021). Similar results were found by Caughey & Thomas (2022), who suggested that better SLJ performance was associated with 40-yard dash times ($r = -0.86$), indicating that the farther jump correlates with fast running, and also by Lin et al (2023) in a recent systematic review and meta-analysis encompassing trained adults who confirmed strong consistent associations between SLJ distance and maximal running speed (0–100 m) (Lin et al., 2023). Additionally, Singh et al. (2023) found a strong link between vertical jumping ability and agility in athletes. Their research showed that athletes who could jump higher were also more agile.

While correlations between motor skills that are mainly based on lower-body abilities, such as running and jumping, are reasonable, it is interesting to see if similar correlations exist between skills that utilize abilities of different body parts, such as throwing a ball and jumping.

Caughey & Thomas (2022) found strong positive correlations between the SLJ and shot put distances in high school athletes ($r = 0.89$) (Caughey & Thomas, 2022). Similarly, some studies have indicated that jumping tests, such as vertical jump or broad jump, are correlated with shot put performance ($r \geq 0.43$) (Judge & Bellar, 2012; Judge et al., 2013; Kyriazis et al., 2009). Habib et al. (2021) found a significant relationship between jump capacity and the speed of throwing a ball. Their findings suggest that both jump capacity and skeletal muscle

mass are important factors for ball-throwing performance. Therefore, athletes with higher jumping ability and greater muscle mass tend to demonstrate superior throwing speed.

While previous studies have focused on adult athletes or basketball players over the age of 20 (Habib et al., 2021; Mishra & Rathore, 2016; Singh et al., 2023), the current study aimed to assess elementary school students and included a larger sample of participants. Based on the above, the current study sought to identify correlations between several sports motor skills taught in elementary schools, as a first step toward reducing the number of assessments needed for student evaluations in physical education classes.

Material & methods

Participants

142 girls from five classes (93 in three 5th-grade classes and 49 in two 6th-grade classes) participated in the study. All of them learned and practiced the skills as part of their physical education classes.

Procedure

Participants attended regular educational classes, during which measurements were taken, as described in the following section.

Dependent variables

-60-meter sprint run (60mR): participants were tested in pairs on a straight track. They stood on the starting line in a high start position, and they started the run with a whistle. They performed the run 2-3 times in each of two physical education classes, and the fastest result (seconds and hundredths of a second) was recorded.

-600-meter run (600mR): participants were tested on a circular track that included 3 laps of 200m, as part of their physical education classes. One measurement was taken, and a week later, another measurement - the fastest result was recorded. The results were collected in minutes and seconds, but to ensure a consistent representation of time measures in the study, all 600-meter running results were converted into seconds.

-High jump (HJ): Participants were tested in accordance with athletics regulations, which included a run toward the takeoff point, a one-legged jump, a flight (scissor-style), and landing on a mat. Three invalid attempts at the same height equaled disqualification and cessation of measurement. The measurements were taken using a rubber band and not a bar. The starting height was 70 cm, and in case of failure, it was lowered to 65 cm. Then, the height was raised by 5 cm each time. Participants who were afraid to try were reported as having "missing items", while those who were unable to pass the initial height but attempted it received a value of 40. Participants who passed 95 cm received a value of 95, those who passed 1.05 meters received a value of 105, and so on.

-Running long jump (RLJ): Participants were tested according to athletics regulations, which included a fast run toward a takeoff board, a one-legged jump, an airborne flight (sail-style), and a landing in the pit. The closest point to the landing board was used for evaluation. A foul was recorded if they stepped on or beyond the takeoff board. Each participant performed multiple attempts in each of the two assessment sessions. The best result in meters was recorded.

-Standing long jump (SLJ): The jump was performed on a soft surface (artificial grass), from two feet to two feet. The participants stood with their toes just behind the starting line and then performed a countermovement jump forward as far as possible. The distance from the starting line to the participant's rearmost heel was measured, and the best of two trials was recorded to the nearest hundredth of a meter.

-Throwing a ball (TaBall): Participants practiced the overarm throw with a size 0 handball. Afterwards, they made three attempts, and the farthest distance was recorded. A foul was called if the throw was not made in an overarm style or if they crossed the starting line during or after the throw, in accordance with the rules of school athletics competitions.

-Agility: Participants were tested in pairs on a straight track. They performed four 10-meter runs with changes of direction following this procedure: start by standing in a high start position on the starting line. In front of each participant, 10 meters away, there were two cones. Each participant had to run toward the cones, pick up one cone, and place it on the starting line. Then, they ran back to collect the second cone, holding it as they crossed the starting line. Only one attempt for this test was allowed and recorded.

Statistical analysis

The Pearson correlation coefficient was employed to evaluate the relationship between the variables. The strength of the correlation was interpreted according to Schober et al. (2018): values between |0.90 and 1.00| were considered 'very high', |0.70 and 0.89| 'high', |0.40 and 0.69| 'moderate', |0.10 and 0.39| 'weak', and |< 0.10| 'negligible'. To account for multiple comparisons, a Benjamini-Hochberg (BH) correction was applied to control the false discovery rate (FDR) across all statistical tests. Significant results were defined as those with an adjusted p-value (BH) < 0.05. All statistics were performed using JASP (version 0.95.2).

Results

Seven variables were evaluated in the current study: [60m run (60mR), 600m run (600mR), running long jump (RLJ), standing long jump (SLJ), high jump (HJ), throwing a ball (TaBall), and agility run (4x 10 meters)]. Table 1 below presents descriptive statistics of the results.

A total of 142 participants took part in the study; however, as shown, there are some missing data points in each variable. In general, the distribution of data is normal; however, the distribution of the TaBall results indicates a large standard deviation, which is caused by the performance of 28 meters made by one of the participants, who is considered a champion in this competition. It is important to note that since some variables represent running times, a higher numerical value indicates a slower run, while a lower value indicates a faster run.

Table 1: Descriptive statistics of the study's variables

Variable	n	mean	SD	median	min	max	skew	kurtosis	missing
60mR (sec)	136	12.28	1.25	12.12	10.06	16.84	0.70	0.47	6
600mR (sec)	131	206.68	34.63	198	136	321	0.90	1.03	11
HJ (cm)	133	82.52	16.59	85	40	110	-0.89	0.92	9
RLJ (cm)	125	1.99	0.46	1.9	1	3.1	0.25	-0.40	17
SLJ (cm)	129	1.29	0.23	1.3	0.65	1.85	-0.26	-0.08	13
TaBall (cm)	128	11.97	3.81	11.4	2.7	28	1.17	2.67	14
Agility (sec)	129	12.74	1.03	12.64	10.91	16.48	0.65	0.61	13

The correlations between the variables are shown in Table 2. The color scale indicates that darker colors represent stronger relationships, while lighter colors signify weaker ones. The strength of each relationship is presented numerically, with positive values indicating a positive correlation and negative values indicating a negative correlation. Therefore, the significance of the number should be understood as explained below.

Table 2: correlations between the research variables

	60mR	600mR	HJ	RLJ	SLJ	TaBall	Agility
60mR		+0.64*	-0.58*	-0.73*	-0.66*	-0.45*	+0.80*
600mR	+0.64*		-0.44*	-0.58*	-0.52*	-0.17	+0.59*
HJ	-0.58*	-0.44*		+0.65*	+0.64*	+0.33*	-0.48*
RLJ	-0.73*	-0.58*	+0.65*		+0.61*	+0.52*	-0.70*
SLJ	-0.66*	-0.52*	+0.64*	+0.61*		+0.41*	-0.62*
TaBall	-0.45*	-0.17	+0.33*	+0.52*	+0.41*		-0.45*
Agility	+0.80*	+0.59*	-0.48*	-0.70*	-0.62*	-0.45*	

*p_{BH}<0.001

As shown in Table 2, the highest correlation was found between 60mR and Agility ($r=0.80$), followed by high correlations between 60mR and RLJ ($r=-0.73$), and between RLJ and Agility ($r=-0.70$).

Moderate correlations were found between SLJ and TaBall ($r=0.41$), 600mR and HJ ($r=-0.44$), Agility and TaBall ($r=-0.45$), 60mR and TaBall ($r=-0.45$), HJ and Agility ($r=-0.48$), RLJ and TaBall ($r=0.52$), 600mR and SLJ ($r=-0.52$), 600mR and RLJ ($r=-0.58$), 60mR and HJ ($r=-0.58$), 600mR and Agility ($r=0.59$), RLJ and SLJ ($r=0.61$), SLJ and Agility ($r=-0.62$), 60mR and 600mR ($r=0.64$), HJ and SLJ ($r=0.64$), HJ and RLJ ($r=0.65$), and between 60mR and SLJ ($r=-0.66$).

Weak correlations were found between HJ and TaBall ($r = 0.33$), and the lowest and non-significant correlations were found between 600mR and TaBall ($r = -0.17$, $p_{BH} = 0.06$).

Discussion

The findings of the current study suggest that there are general motor abilities (Lee & Schmidt, 2025) common across different skills, particularly given the strong correlations observed between the 60-meter sprint, the long jump, and agility.

These relationships, alongside additional moderate to high correlations, suggest that attributes such as speed, explosive power, muscular strength, coordination, and timing form a shared foundational framework for a range of athletic skills. It appears that these abilities complement each other, allowing for enhanced overall athletic performance, enabling individuals who demonstrate proficiency in one area to excel in other athletic domains (Čaušević et al., 2021; Mishra & Rathore, 2016).

On the other hand, the study reveals clear exceptions, notably the relatively low correlations for the high jump and ball throwing, as well as the particularly weak and non-significant correlation between the 600-meter run and ball throwing. These findings highlight the importance of motor ability specificity, as demonstrated in Henry's hypothesis (1968). This contrast highlights that, while there are many shared factors, some skills require unique physical and biomechanical abilities that are different from one another (Hudgins et al., 2013). This

conclusion reinforces the integrative approach common in sports science today, which recognizes that some abilities are general and interconnected, while others are specific and require separate effort consideration.

One of the more interesting findings in the current study is the moderate correlation between 'lower-body skills' (i.e., Agility, SLJ, 60mR, and RLJ) and ball-throwing performance. Although ball-throwing is not an official sport, it is practiced in elementary schools as preparation for the shot put. While the technique varies, both shot put and throwing a ball depend on upper-body strength, especially the muscles involved in the body's rotation and the throwing arm. Possible explanations for the moderate correlation might stem from shared biomechanical and physiological determinants.

In the long jump (and short runs, such as the 60mR and the Agility task), successful performance relies on the ability to produce large ground reaction forces within a short contact time during takeoff, converting horizontal approach speed into both vertical and horizontal velocity for flight. This requires high force development rates and efficient limb movement sequencing (Čoh, Žvan & Kugovnik, 2017). Similarly, throwing performance heavily depends on the ability to rapidly transfer force through the kinetic chain, from the lower body to the trunk and upper limbs, to maximize release velocity (Calcei & Freehill, 2021; Lehman, Drinkwater, & Behm, 2013). This ability depends on the muscle fiber composition and efficient muscle architecture that support explosive strength and power output (Zaras, Stasinaki, & Terzis, 2021), as well as the ability to properly utilize the stretch-shortening cycle during eccentric phases (Struzik et al., 2021). This ability also depends on the stiffness of the support leg (during running or jumping) or the throwing arm (when throwing a ball). Furthermore, biomechanical analyses of sprinting demonstrate that ground reaction force characteristics, particularly during acceleration, are essential for horizontal propulsion (Nagahara, Mizutani, Matsuo, Kanehisa, & Fukunaga, 2018), supporting both the long jump approach and the momentum needed for throwing.

Finally, countermovement jump height or distance, as well as related biomechanical variables, are associated with broader measures of athletic explosiveness across team sports, emphasizing the shared underlying qualities of explosive power, coordination, and neuromuscular efficiency (Bygate-Smith, Beaven, & Drury, 2025). Additionally, maximal strength acts as a foundation for increasing speed and power levels (Wang et al., 2021). Studies also show that exercises enhancing lower-body explosiveness, such as squats and plyometric jumps, are strongly associated with improvements in sprinting, jumping, and throwing velocity (Requena, García, Requena, de Villarreal, & Cronin, 2011; Lehman et al., 2013).

Overall, these findings support that the biomechanical overlap in explosive force production, rate of force development, and kinetic chain coordination explains the moderate correlations between short runs (i.e., 60mR and the Agility test), long jump, and throwing performances found in the current study.

Conclusions

The results of this study suggest that several common motor skills have a strong shared foundation. Specifically, short sprinting (60m run), agility, and jumping tasks showed strong connections, indicating that speed, explosive lower-body power, coordination, and neuromuscular efficiency are essential general abilities that support performance in various athletic activities. For physical education teachers and coaches, this emphasizes the importance of cultivating these core skills early, as gains in one area are likely to transfer to others. At the same time, the results also highlight the importance of motor ability specificity. The relatively weak correlations between ball throwing and the 600-meter run suggest that endurance-oriented and upper-body-focused skills impose different physiological and biomechanical demands on the body. This indicates that while general training can improve overall athletic ability, specific skills, such as throwing technique or aerobic endurance, require targeted practice and should not be expected to improve automatically through general conditioning alone.

The moderate correlations between lower-body explosive tasks and ball-throwing performance indicate a partial overlap in movement coordination and force generation across the kinetic chain. From a practical perspective, this supports including full-body strength and power exercises (such as plyometrics, sprint drills, and multi-joint strength movements) in youth training programs, as these activities can help improve a variety of motor skills, including throwing performance.

Overall, the results support a balanced approach to physical education and youth training. Focusing on general motor development through sprinting, jumping, and agility exercises can create a broad athletic foundation, while skill-specific drills are still vital for improving endurance and upper-body tasks. This approach may enhance performance, lessen early specialization, and encourage long-term athletic growth in school-aged populations. It would be interesting to repeat the study with adolescents, especially from ninth grade onward, a time marked by significant physical, psychological, and social changes (Boțilă et al., 2025) and sports specialization (Brenner, 2016; Co'te', Baker, & Abernethy, 2007).

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used Grammarly (v1.2.220.1800) in order to improve English language editing.

After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Conflict of interest None disclosed.

Ethics statement The studies involving human participants were reviewed and approved by the Institutional Ethics Committee of Givat Washington College (No. 9), and the Chief Scientist of the Israeli Ministry of Education (No. 14528). The parents of the participating students expressed no objection to their children's participation in the study.

Funding This publication was made possible by a grant from Givat Washington Academic College of Education.

References

- Boțilă, V., Mihăilescu, L. N., Butnariu, M., Georgescu, L., Alecu, A., Constantin, A., & Enache, I.-S. (2025). Trends in the development of effort and motor skills in ninth graders. *Journal of Physical Education and Sport*, 25(6), 1131–1140.
- Brenner, J. S. (2016). Sports specialization and intensive training in young athletes. *Pediatrics*, 138(3).
- Button, C., Seifert, L., Chow, J. Y., Araujo, D., & Davids, K. (2021). *Dynamics of skill acquisition: An Ecological Dynamics Approach* (2nd ed.). Human Kinetics.
- Bygate-Smith, M. K., Beaven, C. M., & Drury, M. (2025). Physical and biomechanical relationships with countermovement jump performance in team sports: Implications for athletic development and injury risk. *Sports*, 13(8), 277.
- Calcei, J. G., & Freehill, M. T. (2021). The science and biomechanics of long-toss. *Current Reviews in Musculoskeletal Medicine*, 14(3), 224–231.
- Cattuzzo, M. T., dos Santos Henrique, R., Ré, A. H. N., de Oliveira, I. S., Melo, B. M., de Sousa Moura, M., ... & Stodden, D. (2016). Motor competence and health related physical fitness in youth: A systematic review. *Journal of Science and Medicine in Sport*, 19(2), 123–129.
- Caughey, R. M., & Thomas, C. (2022). Variables associated with high school shot put performance. *International Journal of Exercise Science*, 15(6), 1357.
- Čaušević, D., Abazović, E., Mašić, S., Hodžić, A., Ormanović, Š., Doder, I., ... & Lakota, R. (2021). Agility, sprint and vertical jump performance relationship in young basketball players. *Acta Kinesiologica*, 1, 133–137.
- Cleland-Donnelly, F., Gallahue, D. L., & Mueller, S. S. (2016). *Developmental physical education for all children: Theory into practice* (5th ed.). Human Kinetics.
- Co'te', J., Baker, J., & Abernethy, B. (2007). Practice and play in the development of sport expertise. In G. Tenenbaum & E. Eklund (Eds.), *Handbook of sport psychology* (3rd ed.) (pp. 184–202). John Wiley & Sons.
- Čoh, M., Žvan, M., & Kugovnik, O. (2017). Kinematic and biodynamic model of the long jump. *Kinematics*, 113.
- Goodway, J. D., Ozmun, J. C., & Gallahue, D. L. (2021). *Understanding motor development: Infants, children, adolescents, adults: Infants, children, adolescents, adults* (8th ed.). Jones & Bartlett Learning.
- Guo, X., Li, C., Zhang, Z., Silva, A. F., & Clemente, F. M. (2024). Can motor competence be influenced by the type of training interventions preschool children are exposed to? A randomized experimental study comparing sports games and psychomotricity activities. *Frontiers in Psychology*, 15, 1476297. <https://doi.org/10.3389/fpsyg.2024.1476297>
- Habib, I., Ahmed, A. M., El-Saied, M. A., & Mostafa, H. S. (2021). Speed and throwing the ball are related to jump capacity and skeletal muscle mass in university basketball players. *The Journal of Sports Medicine and Physical Fitness*, 61(6), 771–778.
- Henry F. M. (1968) Specificity vs. generality in learning motor skill. In R. C. Brown & G. S. Kenyon (Eds.), *Classical studies on physical activity* (pp.331–340). Prentice Hall.
- Hudgins, B., Scharfenberg, J., Triplett, N. T., & McBride, J. M. (2013). Relationship between jumping ability and running performance in events of varying distance. *The Journal of Strength & Conditioning Research*, 27(3), 563–567.
- Judge, L. W., Bellar, D., Thrasher, A. B., Simon, L., Hindawi, O. S., & Wanless, E. (2013). A pilot study exploring the quadratic nature of the relationship of strength to performance among shot putters. *International Journal of Exercise Science*, 6(2), 171.
- Judge, W. L., & Bellar, D. (2012). Variables associated with the of personal best performance in the glide and spin shot put for US collegiate throwers. *International Journal of Performance Analysis in Sport*, 12(1), 37–51.
- Kyriazis, T. A., Terzis, G., Boudolos, K., & Georgiadis, G. (2009). Muscular power, neuromuscular activation, and performance in shot put athletes at preseason and at competition period. *The Journal of Strength & Conditioning Research*, 23(6), 1773–1779.
- Lee, T. D., & Schmidt, R. A. (2025). *Motor learning and performance: From principles to application* (7th ed.). Human Kinetics.
- Lehman, G., Drinkwater, E. J., & Behm, D. G. (2013). Correlation of throwing velocity to the results of lower-body field tests in male college baseball players. *The Journal of Strength & Conditioning Research*, 27(4), 902–908.

- Li, Y., Wu, X., Ye, D., Zuo, J., & Liu, L. (2025). Research progress on the relationship between fine motor skills and academic ability in children: a systematic review and meta-analysis. *Frontiers in Sports and Active Living*, 6, 1386967.
- Lin, J., Shen, J., Zhang, J., Zhou, A., & Guo, W. (2023). Correlations between horizontal jump and sprint acceleration and maximal speed performance: a systematic review and meta-analysis. *PeerJ*, 11, e14650.
- Liu, Y., Li, Z., Yuan, L., & Zhou, Z. (2023). *The bidirectional correlation between fundamental motor skill and moderate-to-vigorous physical activities: A systematic review and meta-analysis*. *Children*, 10(9), 1504. <https://doi.org/10.3390/children10091504>
- Logan, S. W., Ross, S. M., Chee, K., Stodden, D. F., & Robinson, L. E. (2018). Fundamental motor skills: A systematic review of terminology. *Journal of Sports Sciences*, 36(7), 781–796. <https://doi.org/10.1080/02640414.2017.1340660>
- Lopes, L., Santos, R., Coelho-e-Silva, M., Draper, C., Mota, J., Jidovtseff, B., ... & Agostinis-Sobrinho, C. (2021). A narrative review of motor competence in children and adolescents: What we know and what we need to find out. *International Journal of Environmental Research and Public Health*, 18(1), 18. <https://doi.org/10.3390/ijerph18010018>
- Loturco, I., Fernandes, V., Boullousa, D. A., Siqueira, F., Nakaya, K., Carraco, D., ... & McGuigan, M. R. (2021). Correlations between jump measures and competitive performance remain stable over time in top-level sprinters. *The Journal of Sports Medicine and Physical Fitness*, 61(9), 1202-1207.
- Magill, R. A., & Anderson, D. I. (2017). *Motor learning and control: Concepts and applications* (11th ed.). McGraw-Hill Education.
- Mishra, M. K., & Rathore, V. S. (2016). Speed and agility as predictors of long jump performance of male athletes. *Turkish Journal of Sport and Exercise*, 18(2), 27-33.
- Nagahara, R., Mizutani, M., Matsuo, A., Kanehisa, H., & Fukunaga, T. (2018). Association of sprint performance with ground reaction forces during acceleration and maximal speed phases in a single sprint. *Journal of Applied Biomechanics*, 34(2), 104-110.
- Novotná, T., Ružbarská, I., Leütterová, D. F., & Kress, J. (2025). Motor competence in primary school children: A comparative study of two assessment methods. *Journal of Physical Education & Sport*, 25(7).
- Payne, V. G., & Isaacs, L. D. (2020). *Human motor development: A lifespan approach* (10th ed.). Routledge.
- Requena, B., García, I., Requena, F., de Villarreal, E. S. S., & Cronin, J. B. (2011). Relationship between traditional and ballistic squat exercise with vertical jumping and maximal sprinting. *The Journal of Strength & Conditioning Research*, 25(8), 2193-2204.
- Schmidt, R. A., Lee, T. D., Winstein, C., Wulf, G., & Zelaznik, H. N. (2018). *Motor control and learning: A behavioral emphasis*. Human kinetics.
- Schober, P., Boer, C., & Schwarte, L. A. (2018). Correlation coefficients: appropriate use and interpretation. *Anesthesia & Analgesia*, 126(5), 1763-1768.
- Singh, A., Nagar, M., Sharma, M., & Shenoy, S. (2023). Investigating the correlation between agility and jump performance indices in Indian contact sports persons: An observational study. *Journal of Modern Rehabilitation*, 17(4), 420–427.
- Smith, L. B., & Gasser, M. (2005). The development of embodied cognition: Six lessons from babies. *Artificial Life*, 11(1–2), 13–29. <https://doi.org/10.1162/1064546053278973>
- Stodden, D. F., Goodway, J. D., Langendorfer, S. J., Robertson, M. A., Rudisill, M. E., Garcia, C., & Garcia, L. E. (2008). A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. *Quest*, 60(2), 290-306.
- Struzik, A., Karamanidis, K., Lorimer, A., Keogh, J. W., & Gajewski, J. (2021). Application of leg, vertical, and joint stiffness in running performance: A literature overview. *Applied Bionics and Biomechanics*, 2021(1), 9914278.
- Thelen, E. (2005). Dynamic systems theory and the complexity of change. *Psychoanalytic Dialogues*, 15(2), 255–283. <https://doi.org/10.1080/10481881509348831>
- Wang, L., Yin, L., Zhao, Y., Su, Y., Sun, W., Chen, S., ... & Engelke, K. (2021). Muscle density, but not size, correlates well with muscle strength and physical performance. *Journal of the American Medical Directors Association*, 22(4), 751-759.
- Zaras, N., Stasinaki, A. N., & Terzis, G. (2021). Biological determinants of track and field throwing performance. *Journal of Functional Morphology and Kinesiology*, 6(2), 40.