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Impact of the Run, Jump, Throw Program on Fundamental Motor Skills in School-Aged Children

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Abstract

Fundamental motor skills and physical activity are essential in the health and well-being of children, building the structural framework for future health and wellness. The Run-Jump-Throw Program targets fundamental motor skills in school aged children. A six-week intervention using the Run-Jump-Throw program was implemented in children kindergarten through 5th grades to increase fundamental motor skills/physical activity. Students (n=135) participated in a 30-minute Run-Jump-Throw program once a week for six weeks. Portions of the BruininksOseretsky Test of Motor Proficiency Edition 2 (BOT-2) were used to assess baseline and post intervention outcomes. Statistically significant improvements were found for the object control (catching and throwing), standing long jump, and running speed and agility skills. Sexdifferences were found for standing long jump,and catching and throwing. Short term participation in structured programs, like the Run-Jump-Throw Program, can improve the fundamental motor skills in school-age-children.

Key words: fundamental motor skills, school age children, intervention, BruininksOseretsky Test of Motor Proficiency Edition 2 (BOT-2)

Introduction

Physical literacy (PL) and fundamental motor skills (FMS) are important components in children's motor development and the structural foundation for building lifelong engagement in health and physical activity (PA) (Cornish et al., 2020; Jiménez-Díaz et al., 2019). Fundamental motor skills are the building blocks of movement and involve the body's large muscles pertaining to locomotor (movements of the body from one spot to another, e.g., jumping, running) and object control (catching, throwing, kicking manipulation) (Cameron et al., 2016). Some researchers also consider stability skills (balance, movement of the trunk, limbs, and posture) as a component of fundamental motor skills (Gallahue& Donnelly, 2007; Veldman et al., 2019); however, stability skills are not often included within larger studies of fundamental motor skills in children.

In general, motor development is defined as the changes in motor behavior over the lifespan and the process(es) which underlie these changes (Haywood & Getchell, 2019). For example, by three years of age, children can run, jump up in the air, and balance briefly on one leg. Four-year-old's can hop on one foot and gallop, five-year-old's walk forwards on a balance beam and skip, and seven-year-olds can throw and catch a ball (Cech & Martin, 2012). These fundamental motor skills are critical in the promotion and maintenance of healthy developmental trajectories, as children utilize these skills to perform functional tasks. Moreover, these skills have been linked to positive health outcomes and successful participation in sport and physical activity across the lifespan (Eather et al., 2018; Gallahue et al., 2012). Engel and colleagues (2018) found that low FMS were associated with low levels of PA in school-aged-children. FMS are not naturally acquired during the process of motor development (Hardy et al., 2010) and the motor learning literature outlines that most children are developmentally capable of mastering all FMS by Grade 4 (approximately 10 years of age) through the provision of developmentally appropriate activities and equipment, appropriate visual demonstrations of skills, instruction and feedback, sufficient opportunities for children to practice variety of relevant, enjoyable and challenging practice activities, and a positive learning environment (Gallahue & Ozmun, 2006).

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Improvement of Fundamental Motor Skills

Sixty percent of typically developing children should be proficient in fundamental movement skills by 10 years of age (Cech& Martin, 2012), but many are falling behind (Eather et al., 2018). These skills do not form on their own and require practice to develop appropriately (Eather et al., 2018). Typically developing children have the ability to improve motor skills by participating in a structured physical education program at school. However, with no crossover from one skill to another, it is important that programs incorporate a variety of skills. Motor skill interventions are the most superior type of movement program for improving motor competence in children (Jiménez-Díaz et al., 2019). A systematic review by Zeng and colleagues (2017) found that 8 out of 10 randomized control trials resulted in significant improvements in motor skills of children who participated in structured, teacher-led physical activity programs. A study by Ruiz-Esteban and colleagues (2020) found that a 24-week structured activity program resulted in improvements in FMS in typically developing children ages 3-4 years old and structured physical activity is better than free play for motor development. Moreover, a teacher-led physical activity program targeting FMS found substantial improvements in skills, with school aged children making with the greatest improvementsin throwing and kicking as initially they scored with lowest proficiency. Running skills still significantly improved; however, the effect size was smallerwhen compared to throwing and kicking as 84% of all children were proficient at running prior to any intervention efforts (Mitchell et al., 2013).

Sex Differences

Factors that influence development of fundamental motor skills include genetics, environment, culture and ethnicity, socioeconomic status, and nutrition (Wang et al., 2020). Participation in school-based physical activity has many benefits for motor development in school aged children (Eddy et al., 2019).Although boys and girls are expected to develop fundamental movement skills at the same rate, several studies have reported a significant deficit in age-appropriate object control skills in young girls. Girls have consistently performed lower on overhead tasks (Cech & Martin, 2012;Mitchell et al., 2013) and, in one study, the majority of girls failed to master any of the object control skills tested with the lowest scores reported for hitting with a bat, dribbling, kicking, and overhand throwing (Eather et al., 2018). This same study reported that girls performed much better on locomotion skills such as running, striding, and leaping. Differences in hopping skills have also been documented in the literature. It is common for studies to reportboys asdemonstrating higherperformance than girls in relation to throwing, catching, running and jumping (Duncan et al., 2020). However, there is conflicting evidence when it comes to sex differences in balance skills.Franjoine and colleagues (2010) found that performance on balance items varied by age and child sex. Specifically, younger children scored lower on balance and girls scored higher than boys. However, Davies and Rose (2000) found no evidence of sex differences for balance-related items (e.g., walking on a balance beam, one-legged balance).

Given the conflicting evidence related to balance as a fundamental motor skill and the potential influence of child sex on balance ability, it is important to include the balance subscale of the BOT-2 to examine how balance abilities relate to developmental competencies in other fundamental motor skills. The purpose of the current study was to identify whether a physical literacy development program (i.e., USA Track & Field/Hershey Run Jump Throw program) can be used to enhance physical literacy and improve fundamental motor skill development in a sample of school-aged children.

Methods

Participants

One-hundred and thirty-five students ages 5 – 11 attending a laboratory college prep school in the Appalachian Region participated in the current study. All children in Kindergarten through 5th grade were sent home with a folder of information about the research opportunity. Participation was voluntary and requiredsigned parental consent and verbal or written child assent. The Institutional Research Board approved all procedures.

Materials

Intervention Program. The Run Jump Throw (RJT) program was created by the USA Track & Field and Hershey with the goals of improving foundational movement skills and engaging young children in non-competitive physical activity (USA Track & Field, n.d). Physical literacy programs, such as RJT, are developed to complement other functional motor skill learning environments like physical education. The RJT program addresses typical state physical education standards including helping students learn and refine motor skills and movement patterns, identifying principles of practice and conditioning to enhance movement performance, learning and demonstrating proper warm-up and cool-down techniques, engaging in physical activity to achieve social interaction, and enjoying learning new and challenging physical activities (SHAPE America, 2013).

Participation in the RJT program occurred during school hours and sessions included 30 minutes of activity once a week. The current program was administered during six consecutive weeks. Basic track and field tasks were performed to develop fundamental motor skills (USA Track & Field, n.d). Specifically, activities included skips, broad jump, running form, overhead throws with javelin, and speed hurdles.

BOT-2. The BOT-2 is a screening tool to measure fine and gross motor proficiency among school-aged children to young adults (4-to-21-years of age).The BOT-2 is a norm-referenced outcome measure that compares the performance of a child to that of a normative group and quantifies the movement skill competence of the child. The BOT-2 breaks down components of various motor skills and tests those movements under four motor area composites which are comprised of eight subsets.The eight subsets of the BOT-2 include: fine motor precision, fine motor integration, manual dexterity, upper limb coordination, bilateral coordination, balance, running speed and agility, and strength (Bruininks & Bruininks, 2005).

The BOT-2 was chosen for this study because it has age-specific norms for each of the subsets that are tested. The assessment has excellent test-retest reliability, as well as excellent interraterreliabilityfor children ages 4-12 (ICC ranges from 0.76.- 0.83) (Wuang& Su, 2009; Wuang, Su & Huang, 2012).Finally, the item-reliability of all subtests is excellent (> .95)(Brown, 2019). Together these psychometric characteristics make the BOT-2 an advantageous assessment of motor skills in children.

Portions of the BOT-2 used in the current study consisted of all items in the balance, running speed andagilityand upper limb coordination subtests. The balance subtest consists of nine items. Example items include walking forward on a line, standing on one foot on a line with eyes open, standing on one leg on a balance beam with eyes closed. The running speed and agility subtest consists of five items and includes assessments such as shuttle run, one-legged stationary hop, and two-legged side hop. The upper limb coordination subtest consists of seven items and sample items include throwing a ball at target, dropping and catching a ball with one hand, and dribbling a ball with alternating hands. Only the standing long jump item from the strength subtest was administered in the current study.

Procedure

The administration of the RJT program activities occurred inside in the green space surrounding the local school. The school allowed the research team to use the regularly scheduled physical activity breaks during the school day to administer the RJT program and complete BOT-2 testing. Because different grade levels have physical activity breaks at different times during the school day, the research team was able to work with one grade level at a time. The BOT-2 baseline and posttest collection took place across two days in one week and each grade was tested together. That is, all BOT-2 data for the 4th grade students was collected together, all BOT-2 data for the 2nd grade students was collected together. Students were placed into small groups and pseudo-randomly rotated through the stations until all stations were visited. This is "carnival style" administration of the BOT-2 has been used in previous research with children (Warner et al., 2021). One week prior to start of the RJT program, the BOT-2 was administered to establish baseline fundamental motor skill levels. The BOT-2 was administered again one week aftercompletion of the RJT program. Due to changing weather conditions and space constraints, both indoor and outdoor locations were used for various BOT-2 subtests across grade levels.

Trained research assistants administered the RJT program for 30 minutes once per week over the course of six weeks.All participants in the study completed the RJT program; there was no control group. Before data collection, all research staff members were provided training on scoring items on the BOT-2 and inter-rater reliability following the training ranged between r =.83 and .99. The BOT-2 standardized script was used to provide instructions to the children. Standard protocol scoring as described in the BOT-2 manual was utilized. After collection of the data on the baseline and posttest BOT-2, raw scores were converted to point scores. For each full subtestcompleted (e.g., balance, running speed and agility, and upper limb coordination), point scores were added together to obtain composite point scores. Composite point scores were then translated into scaled scores by looking at the norms table within the BOT-2 scoring manual. These standardized scaled scores provide adjustments based on normed data on the BOT-2 and are specific to participant sex and age (Bruininks & Bruininks, 2005).

Scaled scores are useful, in addition to composite point totals, because theyprovide an alternative way ofexamining changes in performance over time. For example, a participant's composite point score may indicate they improved their score on the balance subtest by two points. However, the interpretation of a two-point improvement is not very intuitive to those unfamiliar with the BOT-2 scoring system.

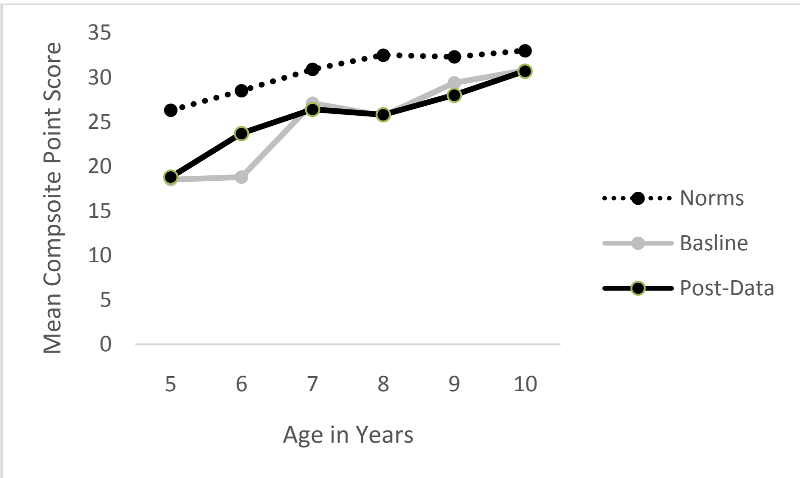
In contrast, the descriptive category changes over time may indicate that a participant's performance on the balance subtest changed from "below average" to "average" after completing the intervention. Thus, the quantitative shift in composite point totals and qualitative shifts in descriptive categories provide a clear picture of performance. The composite point totals were assigned a descriptive category based on the following criteria: well below average (5 or less); below average (6-10); average (11-19); above average (20-24); and well above average (25 or greater). Because post testing occurred three months after baseline testing, 12-weeks were added to each child's age when translating for scaled scores. Statistical Package for the Social Sciences (SPSS) version 27.0 was usedfor all analyses.

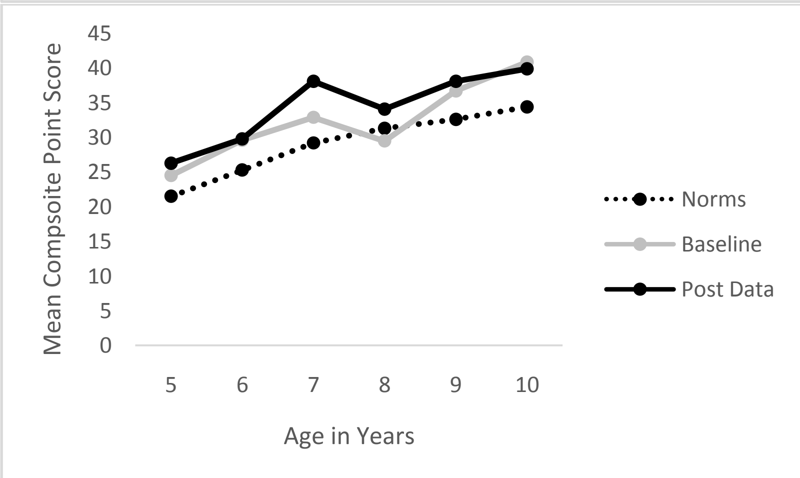
Results

Participant demographics are presented in Table 1. The mean composite point totals for each subtest of the BOT-2 are described in Table 2. BOT-2 subtests examining balance, running speed and agility, upper limb coordination, and the individual test item of standing long jump are described below. Moreover, Figure 1 visually displays participant baseline and posttest scores alongside of normed data on the BOT-2 for the Balance, Running Speed and Agility, and Upper Limb Coordination subtests.

Table 1: Frequency and Demographics of Sample

Grade-Level	Frequency (%)	Male (%)
Kindergarten	18 (13.6)	11 (61.1)
1st Grade	22 (16.3)	12 (54.5)
2nd Grade	22 (16.3)	9 (40.9)
3rd Grade	23 (17.0)	13 (56.5)
4th Grade	25 (18.5)	12 (48.0)
5th Grade	25 (18.5)	11 (44.0)
Total	135	68 (50.4)





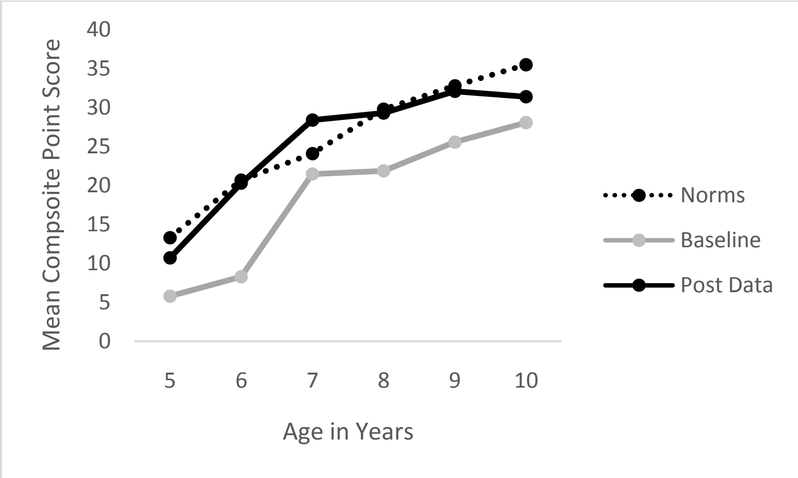


Figure 1. BOT-2 Norms, Baseline and Posttest comparison data. Panel A presents data for balance, Panel B presents data for running speed and agility, and Panel C presents data for upper limb coordination.

Balance

A mixed ANOVA was conducted with time (pre, post) as the within-participant factor and Grade Level (K, 1, 2, 3, 4, 5), and child sex (male, female) as between-participant factors on children's composite BOT scores from the Balance subtest. The main effect of grade was significant whereby children in higher grades scored higher than children in lower grades, $F(1, 115) = 11.91, p<.001, \eta_p^2 = .34$. No other main effect or interaction was significant (all p's > .08).

Running Speed and Agility

A mixed ANOVA was conducted with Time (pre, post) as the within-participant factor and Grade Level (K, 1, 2, 3, 4, 5), and child sex (male, female) as between-participant factors on children's composite BOT scores from the Running Speed and Agility subtest. There were significant main effects of time and grade, whereby children scored higher at posttest than at pretest, $F(1, 116) = 6.34, p = .013, \eta_p^2 = .05$, and children in higher grades scored higher than children in lower grades, $F(1, 116) = 25.14, p<.001, \eta_p^2 = .52$. These main effects were qualified by a significant Time x Grade interaction, $F(5, 116) = 5.43, p <.001, \eta_p^2 = .19$. Post-hoc comparisons with a Bonferroni adjustment for multiple comparisons indicated that Kindergarten and 2ndgrade students' performance significantly improved following the intervention (see Table 1). No other main effect nor interactionswere significant (all p's > .10).

Upper-Limb Coordination

A mixed ANOVA was conducted with Time (pre, post) as the within-participant factor and Grade Level (K, 1, 2, 3, 4, 5), and child sex (male, female) as between-participant factors on children's composite BOT scores from the Upper-Limb Coordination subtest. The main effects of time and grade were significant. whereby children scored higher at posttest than at pretest, $F(1, 115) = 230.37, p< .001, \eta_p^2= .67$, and children in higher grades scored higher than children in lower grades, $F(1, 115) = 53.90, p<.001, \eta_p^2= .70$. These main effectswere qualified by a significant Time x Grade interaction, $F(5, 115) = 5.68, p<.001, \eta_p^2 = .20$. Post-hoc comparisons with a Bonferroni adjustment for multiple comparisons indicated that students'performance in all grade levels significantly improved following the intervention (see Table 1). There was a significant main effect of child sex, $F(1, 115) = 8.88, p = .004, \eta_p^2= .07$ indicating that regardless of grade level or time, males (M = 23.43, SE = 0.61) scored higher than females (M = 20.74, SE = 0.66).

Standing Long-Jump

A mixed ANOVA was conducted with Time (pre, post) as the within-participant factor and Grade Level (K, 1, 2, 3, 4, 5), and child sex (male, female) as between-participant factors on children's standing long jump distances. The main effect of grade was significant. On average, children in older grades scored higher than children in younger grades, $F(5, 100) = 15.18, p<.001, \eta_p^2 = .43$. This effect was qualified by a significant Time x Grade interaction, $F(5, 100) = 4.37, p = .001, \eta_p^2 = .18$.

Post-hoc comparisons with a Bonferroni adjustment for multiple comparisons indicated that 4th and 5th grade students'jumped significantly longer distancesfollowing the intervention. However, 1st grade students' jumped significantly shorter distances (see Table 1). There was a significant main effect of child sex, $F(1, 100) = 19.23$, $p = .001$, $\eta_p^2 = .16$ indicating that regardless of grade level or time, males (M = 49.75, SE = 1.02) scored higher than females (M = 42.74, SE = 1.23). All other main effects and interactions were non-significant (all *p*'s > .132).

Wilcoxon Signed Ranks Test

Because the BOT-2 scoring manual provides translation of composite point scores into ordinal data (e.g., well below average, average, above average), the non-parametricWilcoxon Signed Ranks Test was used to compare changes from baseline to post testing. Across all participants, the results indicated a significant difference in Running Speed & Agility (z=-3.34, *p*= .001) and Upper-Limb Coordination (z=-6.63.34, *p*< .001). However, no statistically significant change was noted between median baseline and post-test scale scores for the Balance subtest, $z = -0.33$, $p = .742$. Median values for the non-parametric analysis are presented in Table 3.

Table 2. Means and Standard Deviations for BOT-2 Assessment at Baseline and Post-Test

Test	BOT 5		BOT 6		BOT 7		Standing Long Jump (inches)	
	Baseline M(SE)	**Posttest M (SE)**	**Baseline M (SE)**	**Posttest M (SE)**	**Baseline M (SE)**	**Posttest M(SE)**	**Baseline M (SE)**	**Posttest M(SE)**
Kindergarten	18.33 (1.82)	19.00 (1.72)	24.67 (1.49)	27.29 (1.48)	5.82 (1.11)	11.94 (2.18)	34.86 (1.42)	36.94 (2.27)
1st Grade	25.00 (0.89)	23.27 (1.01)	30.18 (1.24)	29.14 (1.15)	7.91 (0.94)	20.26 (1.83)	44.76 (2.22)	40.12 (1.66)
2nd Grade	27.35 (1.21)	28.55 (0.91)	34.36 (1.19)	37.59 (0.89)	21.14 (1.25)	28.32 (1.39)	44.38 (1.93)	46.27 (2.03)
3rd Grade	26.57 (1.01)	27.87 (0.75)	37.22 (0.92)	36.70 (0.96)	23.52 (0.94)	28.61 (1.16)	46.46 (2.24)	50.63 (3.57)
4th Grade	29.39 (0.96)	27.68 (0.90)	36.76 (0.71)	38.00 (0.55)	25.58 (1.06)	32.32 (0.78)	47.00 (1.70)	51.20 (2.20)
5th Grade	30.13 (1.00)	30.28 (0.76)	40.10 (0.62)	39.12 (0.90)	27.56 (0.67)	31.84 (1.14)	54.41 (1.92)	58.29 (1.85)
All Grades	26.46 (0.56)	26.46 (0.51)	34.25 (0.59)	35.10 (.055)	19.41 (0.82)	26.51 (0.81)	45.70 (0.92)	47.70 (1.09)

Note: all ages n = 135; BOT subtests: Balance (5), Running Speed and Agility (6), and Upper Limb Coordination (7).

Table 3. Median BOT-2 Values for Balance (5), Running Speed and Agility (6), and Upper Limb Coordination (7) subtests.

	BOT 5		BOT 6		BOT 7	
	Baseline	Posttest	Baseline	Posttest	Baseline	Posttest
Kindergarten	1.22	1.19	2.44	2.50	0.76	1.53
1st Grade	1.36	1.36	1.18	2.45	-	1.94
2nd Grade	1.65	1.63	2.75	2.95	1.55	2.27
3rd Grade	1.31	1.41	2.68	2.59	1.41	1.64
4th Grade	1.26	1.21	2.29	2.38	1.34	1.88
5th Grade	1.54	1.58	2.41	2.40	0.96	1.64
All Grades	1.40	1.40	2.28	2.54	1.22	1.82

Category definitions: 0 = well below average; 1 = below average; 2 = average; 3 = above average; 4 = well above average.

Discussion

The RJT six-week intervention was able to significantly improve participants' standing long jump, running speed and agility, and upper limb coordination scores on the BOT-2. These results provide initial evidence that this program is a viable intervention for increasing fundamental motor skills in children. There is also evidence that the impact may be more substantial for certain children in certain grade levels and may impact boys differently than girls. Furthermore, comparison of children's performance in the current sample to that of a normative group indicates that prior to participation in the brief RJT intervention, on average, children were demonstrating below average movement competencies in the areas of balance and upper limb coordination. Following the RJT intervention, movement competencies related to upper limb coordination were more similar to a normative group; however, balance competency remained below average.

To our knowledge this is this first research study investigating the RJT program's ability to change fundamental motor skills. However, previous research has investigated the impact of similar physical activity interventions in school-settings on children's fundamental motor skills (for reviews see Ruiz-Esteban et al., 2020 and Zeng et al., 2017). These studies provide support for the implementation of structured physical activitiesover free play when looking to improve fundamental motor skills.

The current study has insufficient evidence to conclude that participants are able to transfer explicit lessons in running, jumping, and throwing to skills that are not directly incorporated within the RJT intervention, specifically balance. This null result is interesting because balance is considered a component required for the successful completion of fundamental motor skills such as running and throwing (Roncesvalles et al., 2001). There is disagreement in the literature as to whether balance should be considered a fundamental motor skill (Gallahue et al., 2012). Perhaps the current data provide support for its inclusion as a fundamental motor skill. It seems the intervention was able to improve skills that were explicitly targeted by the intervention. Balance skills were only implicitly incorporated in the RJT intervention. Understanding the role of balance on fundamental motor skills and physical activity warrants additional research. Given the extremely low balance scores observed in the current sample, it seems children may benefit from this type of explicit instruction. It is also possible that the individual balance items within the BOT-2 are not sensitive to balance skills that indirectlyimprove (e.g., core stability, postural control) via improvements in skills like throwing and jumping.

The current study found that boys throwing and catching skills were better than girls throwing and catching skills. This pattern of sex differences is consistent with previous literature (Cech & Martin, 2012; Mitchell et al., 2013). The current study also found boys standing jump distances were longer than girls distances. This is also supported by the previous literature (Emeljanovas et al., 2020; Ramírez-Vélez et al., 2017; Sauka et al., 2011). Sex differences in balance were not found in the current study. The previous literature is less clear here. Some research provides empirical support for girls demonstrating better balance abilities than boys (Jiang et al., 2018; Latorre-Roman et al., 2017; Stanković&Radenković, 2017; Ventasanou&Kambas, 2011) while other research has not found support for such differences (Davies&Rose, 2000; Junaid&Fellowes, 2006).Dobson (2020) has argued that a lack of standardized methodology across studies in measuring balance could be contributing to the disagreement in the literature.

Limitations and Future Directions

The sample was relatively small and only collected from a single school within Appalachian Region.

Thus, the results may not generalize to other populations. Replication of this study with a larger sample of participants from more diverse schools would allow for more confidence in wide application of the RJT intervention. Another possible limitation is that the testing environmentwas not consistent from baseline to posttest due to seasonal changes and space constraints.

For example, the baseline testing was almost entirely collected outside during the early Fall and the post-testing was collected inside and outside due rain and colder weather on the days of testing.The approach to measurement of fundamental motor skills (BOT-2) tests several aspects of motor development that are not explicitly taught during the RJT intervention (e.g., balance, strength). Perhaps a measurement assessment that is directly related to the skills explicitly instructed during the RJT intervention would demonstrate more comprehensive improvement across participants.

Conclusions

A six-week intervention focused on providing children with fundamental knowledge and practice in the areas of running, jumping, and throwing successfully increased participants performance in the areas of running speed and agility and upper limb coordination. The RJT program includes activities targeted at improving physical literacy and this study provides the first piece of evidence that the program may also improve fundamental motor skills in school-aged students.

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