



Assessment of Preschool Children's throwing Ability by throwing Distance and Velocity

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A remarkable decrease in children's throwing ability has recently been reported. Until now, although throwing ability of children has been mainly assessed by distance, velocity has also become easily instrumentally measurable. However, the relationship between the throwing distance and velocity remains unclear. This study examined the age and gender differences in throwing distance and velocity, and their relationship in preschool children. Participants were 270 children (boys: 134, girls: 136), 3–6 year olds. Both the measured values had high reliability (ICC = throwing distance: boys, 0.73, girls, 0.70; throwing velocity: boys, 0.83, girls, 0.78) and were greater in boys than in girls, in 6-year-olds than in 5-year-olds, and in 5-year-olds than in 3- and 4-year-olds. Partial correlation coefficient eliminating age effect was significant (boys: 0.65, girls: 0.53). Correlation at each age was significant and high at 5 and 6 years old ($r = 0.70\text{--}0.76$), but insignificant only in 3-year-old girls. In conclusion, throwing velocity has high reliability, similar to throwing distance, and reflects gender- and age-related differences in preschool children. Although throwing velocity is related to throwing distance, their relationship differs according to children's gender and age.

Keywords: Children; throwing ability; throwing distance; throwing velocity.

1. INTRODUCTION

A decrease in children's physical fitness has become a national problem in Japan. Children's fitness has shown a marked decrease in comparison to that of children in 1985 [1,2]. Along with this, contemporary children's throwing ability has also decreased remarkably [1,2,3].

The main reason seems to be that children's throwing ability has decreased overall because they now play fewer throwing games, and baseball and softball are no longer the major games played by them [4]. In short, children's choice of games has changed greatly. Of course, throwing movement is learned and improved by repeated practice. As running, jumping, and throwing are basic movements in many sports, decreased throwing ability might affect the choice of lifelong sports in adulthood, and improving children's throwing ability will require active effort.

The throwing ability of young children has been assessed by the throwing distance [1-5]. Many studies have reported that their throwing distance increases with age; moreover, the throwing ability is superior in boys as compared to girls [6,7]. Kasuyama et al. [5] reported that the throwing distance of young children is affected not only by age and gender but also by the developmental stage of the throwing motion and grip strength and endurance.

Throwing ability should also be evaluated by throwing accuracy and throwing velocity, depending on its purpose. Miyanishi et al. [8] state, besides throwing long distances, throwing an object fast or accurately should also be assessed because in competitive sports, quickness and accuracy might be more important than distance. Measurements of throwing velocity and accuracy are assessed by initial velocity or a gap from a target when a person threw an object to the target set away from him.

The throwing distance is affected by angle and height in addition to initial velocity [9]. Unlike distance, velocity is not affected by angle and height. However, throwing velocity is closely related to throwing distance, because it is the most important factor for initial velocity in throwing distance. In addition, the accuracy is affected by the distance from the thrower to the target, and a person who can throw an object to a farther distance generally has accuracy as well

[7]. Thus, throwing velocity is closely related to accuracy.

Moreover, the throwing accuracy of preschool children has been studied to some extent. For example, Kano et al. [10] conducted three different target throw tests for preschool children and reported that their test performances improved with age. Ayan et al. [11] reported a significant positive correlation between the target throwing test and age.

Alternatively, there are limited studies that have focused on the throwing velocity of young children. Recently, an inexpensive device that can easily measure the throwing velocity of young children has been developed. Measurement of throwing velocity may be necessary from the viewpoint of the comprehensive evaluation of children's throwing ability. Studies with youth participants reported that the throwing velocity is closely related to the throwing distance [12]. Additionally, Yamada et al. [13] reported that the throwing velocity could be easily and accurately ($R^2 = 0.76$) predicted from the throwing distance of young handball players. As the throwing velocity can be measured in a limited space in a room, it is extremely practical. The throwing velocity may be used as an alternative to the throwing distance in young children.

Although youth have high throwing skills, preschool children's throwing movement is still in the developmental phase [14]. For example, children under 3 years of age have an underdeveloped throwing motion, i.e., they are more likely to throw with their arm without stepping [14]. The maturity of the throwing motion also affects the throwing distance [7]. Therefore, it is assumed that the relationship between preschool children's throwing velocity and throwing distance differs from that of youth. Therefore, this study examined differences in the throwing velocity and throwing distance by age and gender as well as the relationship between velocity and distance.

2. MATERIALS AND METHODS

All participants in this study were children (270 subjects:134 boys; 136 girls) aged 3–6 years old, who belong to three nursery schools in "N" city of "I" prefecture in Japan. These children were in a growth condition similar to that of preschool children in general because their physical

development aligned with that of the standard Japanese values (Table 1).

2.1 Measurement of Throwing Ability

Throwing velocity and distance were measured as an index of throwing ability. In both tests, participants threw a tennis ball overhand.

2.1.1 Measurement of throwing velocity

In a nursery school playroom, participants threw a tennis ball, with full effort, at a net set 5 m in front of them. Throwing velocity (km/s) was

measured by a Doppler radar speed gun (STALKER SOLO2) and displayed immediately afterward. All participants threw twice, and the higher value was considered representative.

2.1.2 Measurement of throwing distance

Throwing distance was measured on a playground. Subjects were instructed to throw a tennis ball as far forward as possible, in 60-degree range from 1 m-diameter circle. All subjects threw twice, and the higher value was considered representative.



Fig. 1. Measurement of throwing velocity



Fig. 2. Doppler radar speed gun (STALKER SOLO2) and LED display



Fig. 3. Measurement of throwing

2.2 Statistical Analysis

Reliability of throwing velocity and throwing distance was examined by Intraclass Correlation Coefficient (ICC). In addition, to compare individual differences, Coefficient of variation (CV) of both the measured values was calculated. A two-way analysis of variance (ANOVA) was used to test differences among means according to gender and age for throwing velocity and throwing distance. Post hoc Tukey's honestly significant difference (HSD) test for multiple comparisons was used if a significant interaction or main effect was found. Pearson product-moment correlation coefficient was calculated by gender to examine the relationship between throwing velocity and throwing distance. In addition, correlation coefficients by age and partial correlation coefficient adjusted by age were calculated because throwing ability develops markedly from infancy. The significance level was set to $p < 0.05$.

3. RESULTS

Reliability (ICC) of throwing velocity was 0.83 for boys and 0.78 for girls. On the other hand, reliability (ICC) of throwing distance was 0.73 for boys and 0.70 for girls. Coefficient of variation (CV) of throwing velocity was 0.22 for boys and 0.19 for girls; throwing distance was 0.41 for boys, and 0.40 for girls. Comparing CV of height (boys: 0.06; girls: 0.07) and weight (boys: 0.14; girls 0.15), the CV of both variables was great, but the CV of throwing velocity was less than that of throwing distance.

Correlation coefficients between throwing velocity and throwing distance were significant and high (boys: 0.75; girls: 0.71). Partial correlation coefficients adjusted by age were 0.65 for boys and 0.53 for girls. Table 1 shows correlation coefficients by gender and age. These coefficients were significant except for 3-year-old girls.

Table 1. Correlation coefficients between throwing velocity and thrown distance

	3 year		4 year		5 year		6 year	
Boy	0.50	*	0.36	*	0.70	*	0.76	*
Girl	0.37		0.54	*	0.62	*	0.52	*

*note: *: $p < 0.05$, Sample size(n)*

Boy : 3 year (17), 4 year (36), 5 year (57), 6 year (24), Girl : 3 year (19), 4 year (39), 5 year (55), 6 year (23)

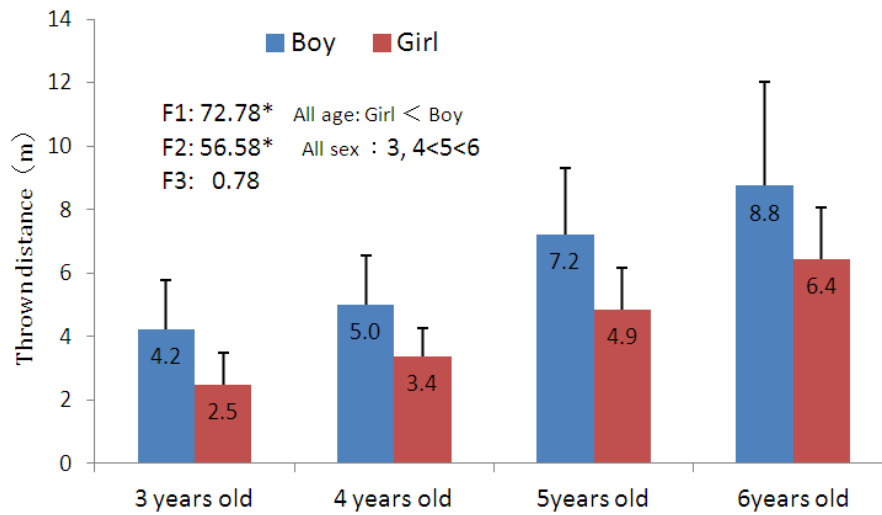


Fig. 4. Means of throwing distance by gender and age Measurement of thrown distance

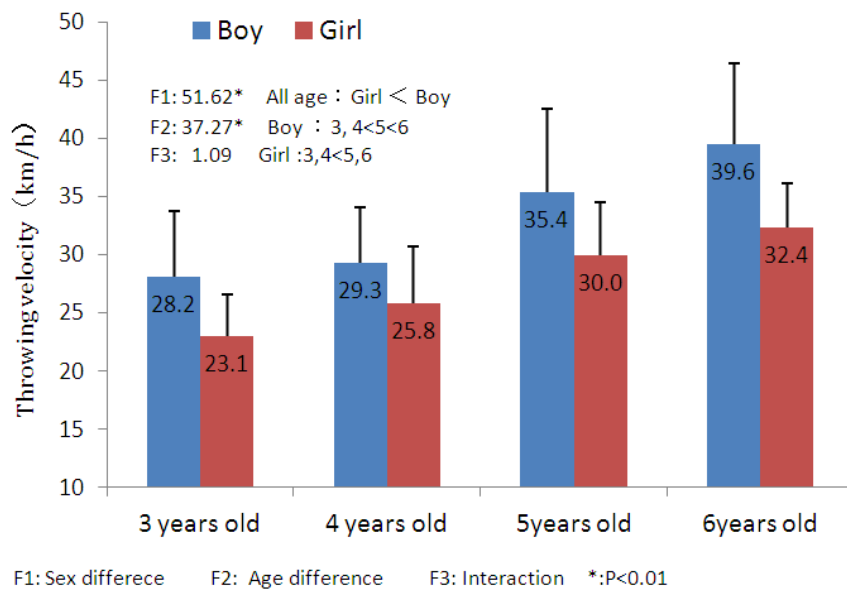


Fig. 5. Means of throwing velocity by gender and age Measurement of throwing distance

Figs. 4 and 5 show means of throwing velocity and throwing distance by gender and age. The results of AVOVA in both variables showed that interaction was not significant, but the main effect of gender and age factors was significant. The results of post hoc showed that the mean for boys was greater than that for girls at all ages. Throwing velocity and throwing distance for boys and throwing distance for girls were higher in 6-year-olds than in 5-year-olds, and higher in 5-year-olds than in 3- and 4-year-olds. Throwing velocity for girls was higher in 5- and 6-year-olds than in 3- and 4-year olds.

4. DISCUSSION

According to a criterion of Landis et al. [15], the reliability of throwing velocity and throwing distance in this study is substantial. In addition, both variables increased with age and were higher in boys than that in girls. A previous study has also reported that preschool boys' throwing ability is superior to girls' [16] and increases with age [14]. This study's results are consistent with of the above-mentioned previous studies results that have assessed throwing ability by throwing distance. Although there are few reports on throwing velocity in preschool children, similar

results have been found on throwing velocity in this study because of the close relationship between throwing velocity and throwing distance. Kasuyama et al. [5] reported that physical factors, such as body size, grip strength, endurance, and throwing motion, affect the throwing distance of young children. Demura [7] inferred that after the throwing movement matures to a certain level, physical fitness factors, such as power and coordination, contribute to the throwing distance. These factors develop with age right from infancy. It is inferred that the body size growth, development of various physical fitness factors, and throwing motion contribute to the increase in throwing distance and throwing velocity as per the increase in the age of infants. Ikeda and Ikeda and Aoyagi [17] reported that gender differences are found in motor ability factors of young children in Japan, and factors in which boys are superior to girls become more evident with age. Nelson et al. [6] examined sex differences in the throwing ability in 5-year-old children, suggesting that biological factors also influence this ability even at the age of 5. It is inferred that sex differences in various motor ability and biological factors in early childhood affect the throwing distance and throwing velocity.

Coefficient of variation (CV) results confirmed that individual differences were greater in throwing distance than in throwing velocity. In addition to initial velocity, when throwing an object, throwing distance is affected by the throw angle and height [9]. On the other hand, throwing velocity is not affected by throw angle and height because it is generally measured when throwing an object toward a target set in a horizontal forward direction. Higher individual differences in throwing distance than that in throwing velocity might be caused by other factors (e.g., angle and height) which are related to it.

Previous studies [12] with young adult participants reported a significant relationship between throwing velocity and throwing distance. Similarly, as mentioned, this study showed a close relationship between velocity and distance, and, to a degree, the relationship differs by age and gender; in short it is higher in boys than that in girls and increases with age.

The following are inferred: Relatively, youth easily throw an object with adequate throwing angle because they have a stable throwing movement. However, preschool children have difficulty because their throwing skill in itself is still developing. Therefore, even if preschool

children's throwing velocity is high, unless they can throw an object with adequate angle, the throw speed might not contribute much to the throwing distance. Kim and Matsuura [14] reported that development of throwing ability differs between genders and that gender differences of throwing distance and throwing movement increase with maturity.

Demura et al. [7] reported that, as they mature, boys' throwing method approaches that of youth's. However, many girls, even at over 5 years old, have immature throwing movement, and the contribution of power to throwing distance is lower in children with immature movement than in those with mature movement. Presumably, boys have more skilled throwing movement than girls at 5–6 years old, and the relationship between throwing velocity and throwing distance becomes higher in boys. Instructions considering gender differences must be followed to improve the throwing ability of young children.

5. CONCLUSION

In conclusion, throwing velocity and throwing distance have high reliability. They increase with age and are superior in boys. The relationship of velocity and distance is close in both girls and boys, and is high especially in 5- and 6-year-old boys. Because of the difference of relationship between throwing distance and throwing velocity in terms of age, further study is required for examining the relationship between velocity and distance while considering the children's developmental stage of throwing movement.

ETHICAL APPROVAL

The Ethics Committee on Human Experimentation of the Faculty of Education, Kanazawa University approved this study (19–14).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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