Original Research Article

Assessment of preschool children's throwing ability by throw distance and velocity

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 throw distance and velocity remains unclear. This study examined the age and gender differences in throw 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 = throw distance: boys, 0.73, girls, 0.70; throw 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 = 0.70~0.76), but insignificant only in 3-year-old girls. In conclusion, throw velocity has high reliability, similar to throw distance, and reflects gender- and age-related differences in preschool children. Although throw velocity is related to throw distance, their relationship differs according to children's gender and age.

Keywords: Children, Throwing ability, Throw distance, Throw 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]. Along with this, contemporary children's throwing ability has also decreased remarkably.

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. 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.

Throwing ability has been assessed by a thrown distance [2,3]. However, as Miyanishi et al. [4] 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 throw 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 throw distance is affected by angle and height in addition to initial velocity [5]. 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 [6]. Thus, throw velocity is closely related to accuracy.

Although in developing the ability to throw, one first picks up the ability to throw an object and then learns to throw it far; for convenience, then, throwing ability is generally assessed by throw distance. However, measurement of throw distance needs space and this can be affected by weather conditions too; so, such measurement is usually conducted outdoors. However, this situation changed recently with the development of an inexpensive instrument for measuring initial velocity. For a good overall evaluation of the throwing ability, it is important also to assess the abilities of throwing quickly and accurately at an object.

Preschool children's throw distance reportedly increases with age and is superior in boys [6]. Although it is thought that throw velocity differs by age and gender, such factors have not been actually reported. On the other hand, studies with youth participants reported that throw velocity is closely related to throw distance [7]. Additionally, Yamada et al. [8] reported that in youth handball players, throw velocity can be easily and accurately (R2=0.76) predicted from throw distance.

Although youth have high throwing skills, preschool children's throwing movement is still in the developmental phase [6]. So, it is assumed that the relationships between preschool children's throw velocity and throw distance differ from that of youth. Therefore, this study examined differences in throw velocity and throw distance by age and gender, and the relationship between the velocity and distance.

2. MATERIAL AND METHODS

Participants in this study were 270 subjects (134 boys; 136 girls), 3–6 years old, who attended 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). The Ethics Committee on Human Experimentation of the Faculty of Education, Kanazawa University approved this study (19–14).

2.1 MEASUREMENT OF THROWING ABILITY

Throw 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 throw velocity

In a nursery school playroom, participants threw a tennis ball, with full effort, at a net set 5 m in front of them. Throw 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.

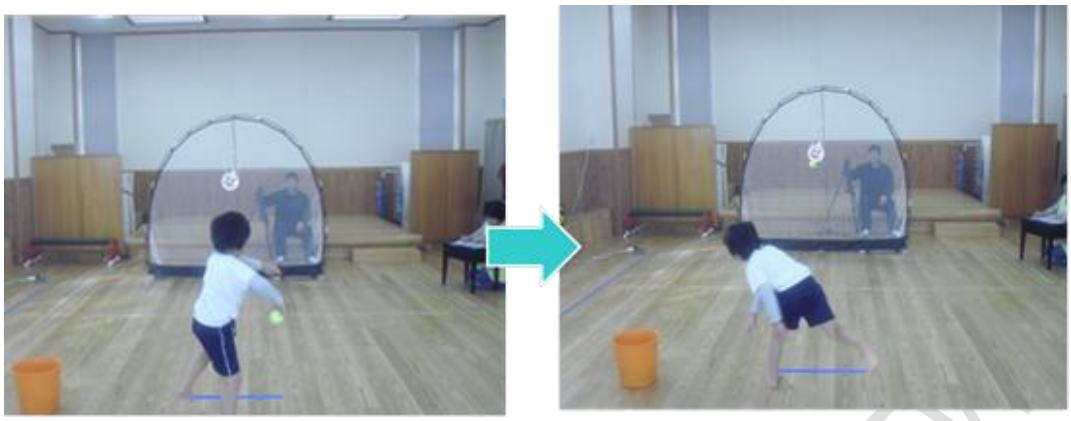


Figure 1. Measurement of throw velocity

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

2.1.2 Measurement of throw distance

Throw 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.

Figure 3. Measurement of throw distance

2.2 STATISTICAL ANALYSIS

Reliability of throw velocity and throw 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 throw velocity and throw 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 throw velocity and throw 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 throw distance was 0.73 for boys and 0.70 for girls. Coefficient of variation (CV) of throw velocity was 0.22 for boys and 0.19 for girls; throw 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 throw velocity was less than that of throw distance.

Correlation coefficients between throw velocity and throw 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)

Figures 4 and 5 show means of throw velocity and throw 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. Throw velocity and throw distance for boys and throw 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. Throw velocity for girls was higher in 5- and 6-year-olds than in 3- and 4-year olds.

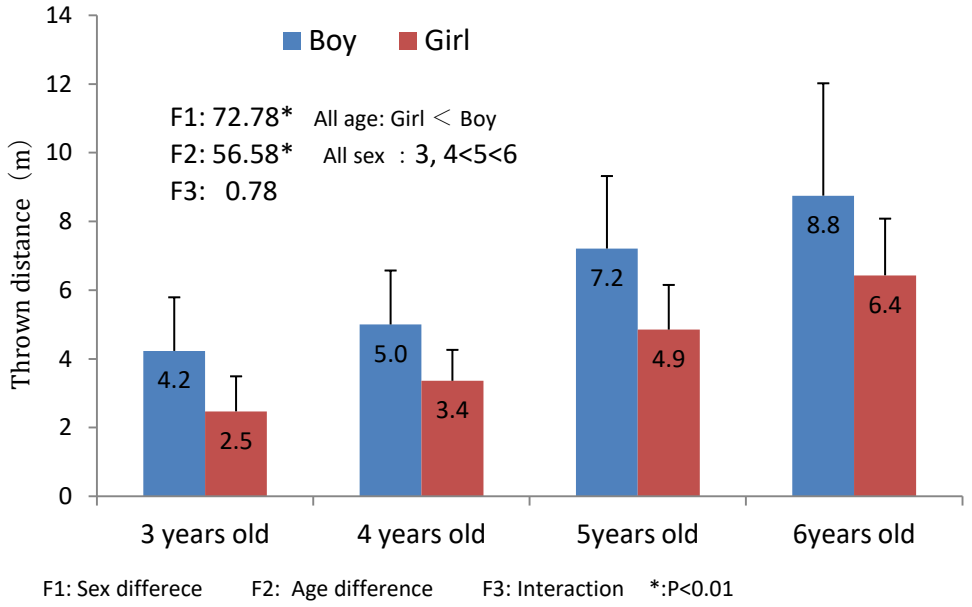
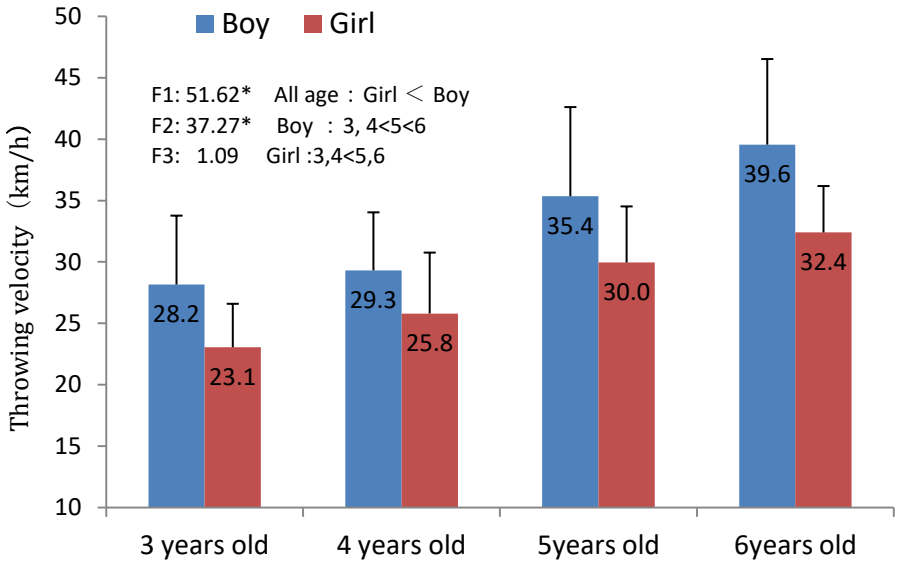


Fig. 4. Means of throw distance by gender and age Measurement of thrown distance



F1: Sex differece F2: Age difference F3: Interaction *:P<0.01

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

4. DISCUSSION

According to a criterion of Landis et al. [9], the reliability of throw velocity and throw 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' [10] and increases with age [2]. This study's results are consistent with of the above-mentioned previous studies results that have assessed throwing ability by throw distance. Although nothing has been reported on preschool children's throw velocity, similar results have be found on throw velocity in this study because of the close relationship between throw velocity and throw distance.

Coefficient of variation (CV) results confirmed that individual differences were greater in throw distance than in throw velocity. In addition to initial velocity, when throwing an object, throw distance is affected by the throw angle and height [5]. On the other hand, throw 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 throw distance than that in throw velocity might be caused by other factors (e.g., angle and height) which are related to it.

Previous studies [7] with young adult participants reported a significant relationship between throw velocity and throw 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 throw velocity is high, unless they can throw an object with adequate angle, the throw speed might not contribute much to the throw distance. Kim and Matsuura [2] reported that development of throwing ability differs between genders and that gender differences of throw distance and throwing movement increase with maturity.

Demura et al. [6] 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 throw 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 throw velocity and throw distance becomes higher in boys.

5. CONCLUSION

In conclusion, throw velocity and throw 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 throw distance and throw 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.

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