論　文

The Effectiveness of Teaching Methods to Improve Throwing Ability for Children: Focusing on Angle of Throwing and Steps

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児童の投能力を改善させる指導法の有効性に関する研究 ― 投射角度とステップに着目して ―

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【要　　旨】

本研究では，中山ら（2014）の投運動学習プログラムに加え，投射角度とステップの指導を行うことで投能力に与える影響を明らかにすることを目的とした．対象は，小学第４学年の児童61名（男子35名，女子26名）であった．調査項目は，遠投距離，観察的評価法による投動作得点，アンケートによる正しい投動作の理解度調査とした．指導法については，中山ら（2014）を参考に，「どすこいバウンド投げ」「振り子投げ」に加えて，「最適な投射角度」と「ステップ」の指導をした．指導の結果，短時間の投射角度とステップの指導を加えた投運動指導が男女別，遠投力高群・低群のいずれにおいても遠投力の向上に効果があることが示唆された．また，投動作，より良い投動作の理解度についても効果が示され，本指導法が児童の投能力の改善に有効であることが示唆された．

【キーワード】

投射角度，どすこいバウンド投げ，振り子投げ，ステップ，小学４年生

【Abstract】

This research aims to clarify the effects produced on throwing abilities by teaching throwing angles and steps in addition to the throwing motion learning program developed by Nakayama et al. (2014). The target of the research was a group of 61 children (35 boys and 26 girls) in the 4th grade of elementary school. The survey items were throwing distance, throwing motions scored via observational evaluation, and level of understanding of correct throwing motions measured through questionnaires. As for teaching methods, the author referred to Nakayama at al. (2014) and taught the most effective throwing angles and steps in addition to the Dosukoi bound throw and the pendulum throw. The results revealed that teaching throwing motions plus briefly teaching throwing angles and steps was effective in improving long-distance throwing ability for

both boys and girls, and for both children who were already good at long-distance throwing and those who were not. Furthermore, the practice was also effective in improving children's throwing motions and their level of understanding of better throwing motions. These findings suggest that this teaching method is effective in improving children's throwing ability.

【Keywords】
Throwing angles, Dosukoi bound throw, pendulum throw, steps, 4th-grade

1. Purpose

According to the "2018 Physical Fitness and Athletic Ability Survey" (the Japan Sports Agency, 2018)[11], the total physical fitness score of fifth graders has been flat for boys and improving for girls since the start of the survey on the new physical fitness tests in 2008. However, the result of items that can be compared with those of 1985 show that more than half of the children scored below the average of 1985 for all exercises except side-to-side jumping. Furthermore, the score for ball throwing is particularly low, and has been on a downward trend since 2010.

Oya (2015)[10] describes the throwing motion as "similar to various motions in goal-type sports such as handball and basketball, and net-type sports such as volleyball, tennis, and badminton," and states that "improving throwing ability is considered to be a foundation for children to do other exercises efficiently and effectively." Therefore, we can expect throwing ability acquisition to be one of the factors that contribute to the realization of an active sports life, which is the goal of PE courses. As mentioned above, however, children's throwing ability still presents some issues.

According to prior research on throwing ability, when Nakayama et al. (2014)[7] conducted a short lesson on throwing motions for elementary school 4th graders, both boys and girls improved their long-distance throwing ability. We can therefore assume that children's throwing ability will improve when they experience correct throwing techniques, even for a short time. Furthermore, Ogata et al. (1996)[8] point out that throwing motions and throwing distance can be improved by learning throwing motions with an emphasis on steps and backswing, while Arikawa et al. (2005)[1] show that children with poor softball throwing results can improve their throwing ability by setting a target angle when they throw.

Hence, this research aims to clarify the effectiveness of supplementing the intervention method of Nakayama et al. (2014) with a short lesson that includes teaching the best throwing angles and steps by referring to the research mentioned above.

2. Methods

(1) Target children

This research targeted a total of 61 children (35 boys and 26 girls) from two 4th grade classes at X Elementary School in Oita Prefecture.

Before conducting the research, the author thoroughly explained the teaching method and how personal information collected through the research would be handled to the principal

and teaching staff of the school, and obtained their consent.

(2) Survey items

In the first survey, before the lesson on softball throwing, the children were allowed to throw freely. In the next survey, measurements were taken after a 30-minute lesson based on the research of Iyoda (1992)[3] and Ogata et al. (2001). In both surveys, the author measured the distance of children's throws, evaluated their throwing motions via video recording, and examined their levels of understanding via questionnaires.

The pre-lesson survey was conducted on June 2, 2014, and the post-lesson survey was conducted on June 9, 2014.

For the evaluation of throwing motions, the observational evaluation method created by Takamoto et al. (2004)[12] was used with some modifications. As for the questionnaire survey, the author created a questionnaire based on the observational evaluation method for throwing motions by Takamoto et al. (2004) and used it to investigate the children's levels of understanding regarding correct throwing motions. The details of each survey item are shown below.

1) Observational method (Takamoto et al. 2004)

Children's throwing motions before and after the lesson were recorded using a video camera and an iPad. Based on the criteria of observational evaluation of throwing motions by Takamoto et al. (2004), seven aspects of throwing motions were evaluated by dividing them into five patterns. The position of the video camera and iPad when recording the motions is shown in Fig. 1. Regarding the "step forward" criterion, the wording of patterns 3, 4, and 5 was modified, as it is preferable to step forward with the foot that is on the opposite side of the hand that throws the ball (Table 1).

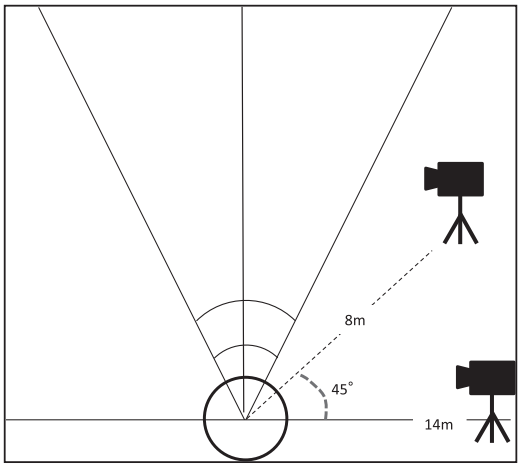


Figure 1. Positions of video camera and iPad

2) Throwing distance

The throwing distance was measured following the method outlined in the New Physical Fitness Test Implementation Guidelines[5] by the Ministry of Education, Culture, Sports, Science and Technology. The children threw a size 1 ball from inside a circle with a radius of one meter. Each child threw the ball twice, and the longer throw was used in the survey. If the distance was outside the measurement range, the throw was invalidated and the child was asked to repeat it.

3) Investigation of children's levels of understanding via questionnaires (Document 1)

Two questionnaires were conducted (before and after the lesson) to find out whether the children understood what they should do to throw the ball farther. The questionnaire included a total of nine questions: the seven evaluation criteria of throwing motions by Takagi et al. (2004), as shown in table 1, plus questions about angles and steps.

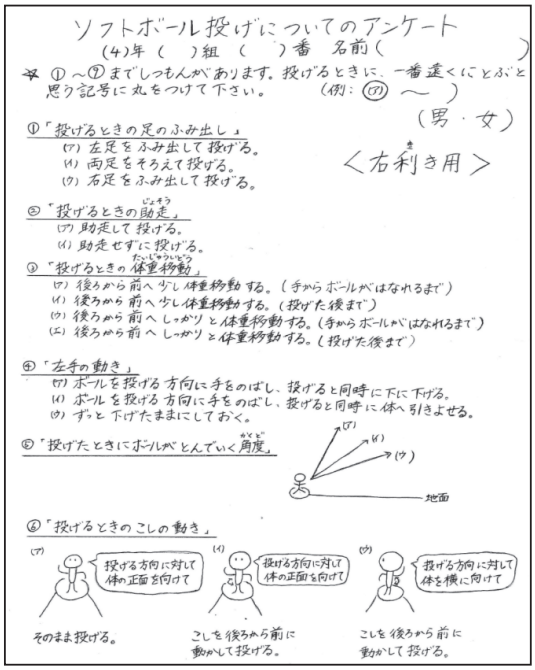
Table 1．Evaluation criteria for throwing motions（based on Takagi et al. 2004 with modifications）

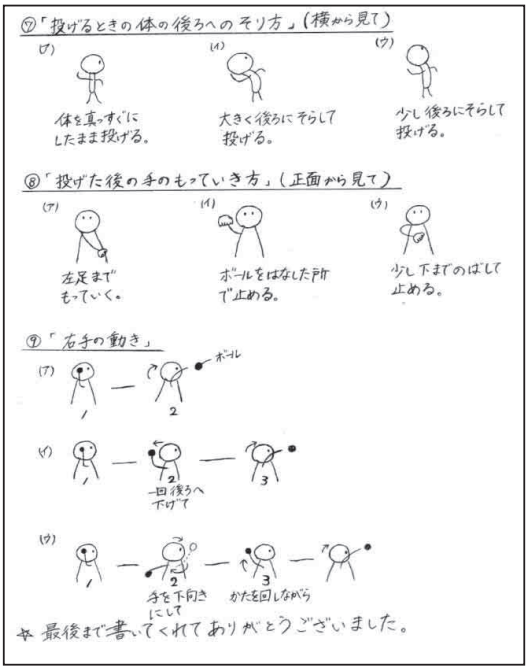
	Pattern 1 (1 point)	Pattern 2 (2 points)	Pattern 3 (3 points)	Pattern 4 (4 points)	Pattern 5 (5 points)
Wrist motion	Keep the elbow bent in front of the body and stretch the elbow forward.	Pull the elbow up while keeping it bent and stretch the elbow downward in front the body.	Rotate the upper arm outwardly and horizontally while keeping the elbow bent and pull up the elbow backward.	The wrist is pulled up backward and rotated anti-clockwise, but the elbow is not sufficiently stretched.	The arm is rotated anti-clockwise with the shoulders as the axis, the elbow is stretched and pulled back further than the shoulder line, and the palm is turned downward in the final phase of backswing.
Backward tilt of the torso at the time of backswing	No backward tilt.	Almost no backward tilt.	Slight backward tilt.	Sufficient backward tilt.	Big backward tilt.
Follow-through	No follow-through.	Almost no follow-through.	Slight follow-through.	Sufficient follow-through downward in front of the body.	Follow-through downward in front of the body on the opposite side of the throwing hand with horizontal shoulder adduction.
Shift of body weight	No shift.	Almost no shift.	The body weight is shifted, but the shift is insufficient at the times of throwing and follow-through.	The shift is sufficient at the time of throwing, but insufficient at the time of follow-through.	The body weight is fully shifted from the back to the front throughout the motion.
Step forward	With feet together, step with the foot on the side of the throwing hand or on the opposite side.	Small step forward with the foot on the side of the throwing hand or on the opposite side.	Step forward with the foot on the opposite side of the throwing hand.	Step forward with the foot on the opposite side of the throwing hand.	Big step forward with the foot on the opposite side of the throwing hand.
	Small step forward with the foot on the side of the throwing hand.		The final movement of the forward step is insufficient.	Although the final movement of the forward step is sufficient, the width of the step is insufficient.	
Rotation of torso	No rotation, the torso faces directly the direction of throw.	The shoulders rotate slightly but the torso faces directly the direction of throw.	The torso rotates backward at the time of backswing.	The torso rotates backward at the time of backswing.	The torso rotates backward beyond the line of the direction of throw at the top of backswing.
				Forward rotation to untwist the torso at the time of throw.	Torso rotation with a shoulder adduction at the time of throw.
Opposite arm of the throwing hand	Kept down.	Thrust slightly forward.	Thrust forward but not pulled back toward the torso at the time of throw.	Thrust forward and pulled back toward the torso at the time of throw.	Thrust forward and pulled back toward the torso at the time of throw.

(3) Lesson content

This research adopted the teaching methods of the Dosukoi bound throw and the pendulum throw developed by Nakayama et al.（2014）and Ogata et al.（2001）[9]. In addition to this, instruction was provided on throwing angles and steps that are closely connected to throwing abilities. The teaching time was just one hour of PE class（45 minutes after explanation and warm-up exercises）. The details of the teaching methods are as follows.

Document 1. Survey items on the level of understanding of the correct throwing motions





1) Dosukoi bound throw

Standing sideways to the throwing direction, raise the foot opposite to the pivot foot like a sumo wrestler stamping their feet firmly on the mound; bring the foot down vigorously and at the same time throw the ball down toward the ground.

2) Pendulum throw

Standing sideways to the throwing direction, cross the wrists so that the throwing hand is over the free hand; from this position, swing both arms in a circular motion on the side of the body while stretching the elbows. When both hands are raised higher than the shoulders, rapidly shift the position to a throwing motion.

3) Throwing angles

Throwing angles are taught before throws themselves. The instructor demonstrates a high-angle throw (about 90°), a medium-angle throw (about 40°), and a low-angle throw (about 20°), and helps children to realize that a 40° angle is suitable for a long-distance throw. In the subsequent practice, the instructor shows a target that makes the throwing angle about 40° and instructs children to throw the ball while aiming at it.

4) Steps

The instructor demonstrates throws with and without steps. Based on research results by Nagano (2018)[6] and Kobayashi (2012)[4], which suggest that the use of onomatopoeic language promotes teaching that captures the sensation of throwing motions, the instructor demonstrates rhythms such as "Tan Ta Tan" and "Tan Tan Tan" and helps the children to visually understand that they can achieve longer throws by doing steps. In the subsequent practice, the instructor proactively talks with the children to see if they are doing what they have been taught. The instructor emphasizes the importance of taking the last step before throwing with the foot that is on the opposite side of the throwing hand.

3. Results

Table 2 shows the overall physical characteristics of the target children, their physical characteristics by gender, and the survey measurements obtained through this research. To clarify the effectiveness of the teaching method on children who already had good long-distances throwing ability (hereinafter referred to as the "high-ability group") and on those who did not ("low-ability group"), the result were analyzed by dividing children into two groups with the national average softball throwing distance for the year 2012 as the demarcation. Since the average throwing distance of 4th-grade boys for the year 2012 was 20.41m, the demarcation for the boys' high-ability group was set at 21m or farther. Likewise, since the average throwing distance of 4 th-grade girls for the year 2012 was 12.10m, the demarcation for the girls' high-ability group was set at 13m or farther.

(1) Throwing distance and throwing motion scores analysis results

Tables 3 and 4 show the analysis results of softball throw measurements (throwing distance) and throwing motion scores. In both cases, data recorded before and after the lesson were compared and analyzed using the corresponding t-test.

A significant improvement (1% to 5%) was found in the throwing distance for all children, the boys' group, the girls' group, and both high-ability groups and low-ability groups. A significant improvement (1%) was also found in the throwing motion scores for all groups.

Results for each of the seven throwing motions were analyzed to clarify which ones had improved. Table 5 shows the t-values of the t-tests that correspond to the data before and after the lesson. A significant improvement at the level of 1% or 5% was found in most phases of the throwing motions.

The only categories where a significant improvement was not found were the girls' "follow-through" and the high-ability groups' "wrist motion" and "follow-through".

Table 6 shows changes in motion scores before and after the lesson in which the children were taught about steps and to focus on the way they stepped forward at the time of throwing. The shaded area shows the number of children who had the same score before and after the lesson. The upper right corner of the shaded area shows the number of children whose throwing motion score for the step forward element increased, while the lower left corner shows the number of children whose throwing motion score for the step forward element decreased. Looking at the rate of changes, the total number of children whose score increased was 40 out of 61 (65.6%), and the number of those whose score decreased was 4 out of 61 (6.6%). Looking at the high-ability groups, the number of children whose score increased was 7 out of 15 (46.7%), and the number of those whose score decreased was 0 out of 15 (0.0%). Furthermore, even in the low-ability groups, the number of children whose score increased was 33 out of 46 (71.7%), and the number of children whose score decreased was 4 out of 46 (8.7%).

(2) Results of the questionnaire survey

The questionnaire consisted of 9 items, and the total score was calculated with each correct answer as 1 point (the total score was in the range of 0 to 9 points). The higher the score, the better the child understood what they should do to throw a ball farther. Table 7 shows the result of the t-test for the scores of

Table 2. Physical characteristics and measurement results (by gender)

Category		All	Boys	Girls
Number of targets	(number)	61	35	26
		Mean SD	Mean SD	Mean SD
Height	(cm)	133.5±6.5	135.1±5.5	131.4±7.0
Weight	(kg)	31.8±6.4	32.9±5.8	30.5±6.8
BMI	(kg/m^2)	23.7±4.1	24.7±3.8	23.1±4.4
Softball throw ①	(m)	14.7±7.5	18.3±7.8	9.9±3.1
Softball throw ②	(m)	15.9±8.0	19.8±8.3	10.5±2.8
Throwing motion score ①	(points)	19.8±5.4	22.2±5.4	16.5±3.2
Throwing motion score ②	(points)	23.5±4.9	25.8±4.8	20.5±2.9
Questionnaire score ①	(points)	4.2±1.8	4.8±1.8	3.5±1.6
Questionnaire score ②	(points)	5.8±1.4	6.0±1.5	5.5±1.3

Table 3. Changes in softball throws before and after the lesson

			Before	After	t-value	t-test
		n	Mean SD	Mean SD		
All	(m)	61	14.7±7.5	15.9±8.0	−4.104	p＜.01
Boys	(m)	35	18.3±7.8	19.8±8.3	−3.616	p＜.01
Girls	(m)	26	9.9±3.1	10.5±2.8	−2.154	p＜.05
High-ability group	(m)	15	23.8±8.5	24.9±9.2	−2.251	p＜.05
Low-ability group	(m)	46	11.7±3.9	12.9±4.8	−3.657	p＜.01

Table 4. Changes in throwing motion scores before and after the lesson

			Before	After	t-value	t-test
		n	Mean SD	Mean SD		
All	(points)	61	19.8±5.4	23.5±4.9	−10.28	p＜.01
Boys	(points)	35	22.2±5.4	25.8±4.8	−7.27	p＜.01
Girls	(points)	26	16.5±3.2	20.5±2.9	−7.23	p＜.01
High-ability group	(points)	15	25.3±5.8	28.5±4.8	−4.26	p＜.01
Low-ability group	(points)	46	18.0±3.7	21.9±3.7	−9.39	p＜.01

Table 5. Changes in motion element scores before and after the lesson (t-value)

Categories	All	Boys	Girls	High-ability	Low-ability
	n=61	n=35	n=26	n=15	n=46
Wrist motion	−6.320 **	−5.560 **	−3.333 **	−1.740	−6.361 **
Backswing	−4.795 **	−3.431 **	−3.353 **	−4.583 **	−3.382 **
Follow through	−2.645 **	−2.260 *	−1.364	−1.146	−2.429 *
Weight shift	−7.815 **	−5.760 **	−5.196 **	−3.500 **	−7.068 **
Step forward	−6.898 **	−4.015 **	−6.374 **	−3.154 **	−6.162 **
Rotation of torso	−7.271 **	−5.632 **	−4.573 **	−4.583 **	−6.001 **
Opposite arm	−4.720 **	−2.589 *	−4.478 **	−2.168 *	−4.155 **

† Backswing : Backward tilt of the torso at the time of backswing　　*p＜.05,　**p＜.01

all children, the boys, the girls, the high-ability groups, and the low-ability groups before and after the lesson.

The results show a significant improvement after the lesson, at the level of 5% for the high-ability groups and at the level of 1% for all children, the boys, the girls, and the low-ability groups.

4. Discussion

This research aimed to clarify the effectiveness of supplementing the intervention method of Nakayama et al. (2014) and Ogata et al. (2001) with a brief teaching program that includes a lesson on the best angle of projection and steps. The research was conducted by examining children's long-distance throwing ability, throwing motions, and level of understanding of the correct throwing motions before and after the lesson. The survey was conducted in two parts: long-distance throwing ability and level of understanding of the correct throwing motions.

Table 6. Changes in throwing motion scores for the step forward element (Cross tabulation)

		After lesson					
	Compulsory	1 point	2 points	3 points	4 points	5 points	Number of children(%)
Before lesson: 1 point	0	0	0	0	0	0(0)
All(number)	0	0	0	0	0	0(0)
High-ability groups(number)	0	0	0	0	0	0(0)
Low-ability groups(number)						
Before lesson: 2 points	0	2	11	13	0	26(42.6)
All(number)	0	0	0	2	0	2(13.3)
High-ability groups(number)	0	2	11	11	0	24(52.2)
Low-ability groups(number)						
Before lesson: 3 points	0	0	1	12	1	14(23.1)
All(number)	0	0	0	2	0	2(13.3)
High-ability groups(number)	0	0	1	10	1	12(26.1)
Low-ability groups(number)						
Before lesson: 4 points	0	1	1	10	3	15(24.6)
All(number)	0	0	0	4	3	7(46.7)
High-ability groups(number)	0	1	0	6	0	8(17.4)
Low-ability groups(number)						
Before lesson: 5 points	0	0	0	2	4	6(9.8)
All(number)	0	0	0	0	4	4(26.7)
High-ability groups(number)	0	0	0	2	0	2(4.3)
Low-ability groups(number)						
Number of children(%)	0(0)	3(4.9)	13(21.3)	37(60.7)	8(13.1)	61
All(number)	0(0)	0(0)	0(0)	8(53.3)	7(46.7)	15
High-ability groups(number)	0(0)	3(6.5)	13(28.3)	29(63.0)	1(2.2)	46
Low-ability groups(number)						

Table 7. Changes in questionnaire scores before and after the lesson

			Before	After	t-value	t-test
		n	Mean SD	Mean SD		
All	(points)	61	4.2±1.8	5.8±1.4	−7.12	p＜.01
Boys	(points)	35	4.7±1.7	6.0±1.4	−4.09	p＜.01
Girls	(points)	26	3.5±1.6	5.5±1.3	−6.66	p＜.01
High-ability groups	(points)	15	5.4±1.9	6.5±1.5	−2.39	p＜.05
Low-ability groups	(points)	46	3.8±1.5	5.5±1.3	−7.24	p＜.01

(1) Comparison of long-distance throwing ability and throwing motions before and after the lesson

A significant improvement (increase) in long-distance throwing ability and throwing motions scores was found for all children, the boys, the girls, the high-ability groups, and the low-ability groups. This suggests that the teaching method used in this research was effective for both genders and regardless of children's original levels of throwing ability.

Ogata et al. (1996) state that throwing motions and throwing distance can be improved by practicing throwing motions with an emphasis on steps and backswing. It seems that the lesson on steps given in this research had a particularly significant impact on the step forward motion. The results show an approximately 50% improvement in the high-ability groups and 70% improvement in the low-ability groups. We can assume that one of the reasons for this improvement in throwing distance is that the children learned a better way to step forward. Since the results of the research by Nakayama et al. (2014) show no improvement in long-distance throwing ability for the high-ability groups after one lesson, there may be a connection between the fact that the children learned the best angle of projection and improved their steps through the lesson, and the improvement in long-distance throwing ability for the high-ability groups.

(2) Level of understanding of the correct throwing motions

Toyoshima (1982)[13] conducted research on the throwing motions of identical twins in elementary school and reported that the level of similarity was extremely low and that the motions differed according to the amount of learning. Hanawa (2008)[2] argues that throwing motions are learned, yet in reality, a decrease in time playing outside due to children's lifestyle and a lack of experience in throwing motions, or inadequate learning of how to throw a ball in the early years of elementary school, resulted in lower throwing ability. Since a short-time teaching program such as the one in this research seemed to still be insufficient in terms of experience, the author thought that helping children to understand the correct throwing motions would lead to improvements in their throwing motions and throwing ability.

The results of surveys before and after the lesson show a significant improvement in children's levels of understanding of the correct throwing motions. Therefore, this research suggests that the teaching program helped the children to understand the correct throwing motions. We can conjecture that what they learned was not simply to throw by imitating the instructor, but also to throw by understanding effective throwing motions. As explained above, progress in such understanding leads to correct throwing motions becoming habitual (sustainable) for children, and can be expected to have long-term, rather than short-term, effects.

(3) Limitations of this research

This research has two main limitations. The first is that the research did not use a control group. In theory, the actual effects of the intervention could have been clarified by examining a group that would receive the lesson and a group that would not. Since this research used only an intervention group, this fact needs to be taken into account when interpreting the results.

The second limitation is the sample size. The targets of this research were a group of children in a single grade of one elementary school in one prefecture. Further research

with a larger sample size is necessary to determine whether this teaching method is effective on children of other elementary schools or other prefectures. These are issues for future research.

Despite the above-mentioned issues, the author hopes that the approach of this research will help children to develop a positive attitude about games and sports that require throwing ability by experiencing the fun and pleasure of improving their throwing distance measurements, and that this in turn will contribute to the lifelong enjoyment of sports which is the goal of PE courses.

5. Conclusion

In this research, the author taught 4th-grade children a lesson on steps and angles of projection based on the teaching method of Ogata et al. (2001), in addition to the short teaching program on the Dosukoi bound throw and the pendulum throw developed by Nakayama et al., (2014) with the aim to clarify the effects of these methods on children's throwing ability. As for research methods, a questionnaire survey was conducted both before and after the lesson to see whether the children knew what they should do to throw the ball farther. As for the throwing distance and throwing motions, actual measurements were used. The main findings are summarized below.

(1) The brief lesson on throwing motions, which included the teaching of angles of projection and steps, was effective in improving long-distance throwing ability for both boys and girls, and for both the high-ability and low-ability groups.

(2) Regarding the teaching of steps, an improvement in the step forward element of throwing motions was seen for all children and for both the high-ability and low-ability groups.

(3) Survey results on children's levels of understanding of the correct throwing motions show that the teaching method in this research helped the children to better understand the correct throwing motions.

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