

OPTIMISATION OF THE SIZE OF A TARGET AND THE THROWING DISTANCE DURING A THROW AT A TARGET FOR ADULTS

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The aim of the study is to optimise throwing distance and the size of a target as a basis for constructing a test of accuracy of a throw at a target, using a tennis ball. The optimal combination must fulfil two conditions – the tested group will achieve an average score of the count of successful hits out of all throws and using a specific combination of the throwing distance and the size of a target and it will fulfil the condition of normal distribution. The tested group consisted of 79 men and 71 women, students of the first year at the Ostrava University in Ostrava, majoring in the Physical Education and Recreation study fields. Three target sizes (0.5, 0.7 and 0.9 m) and three throwing distances (6, 10 and 14 m for men and 4, 6 and 8 m for women) were selected for both categories for the experiment, altogether nine combinations. The score of the experiment is formed by the count of successful hits of the target, out of ten throws, using each combination of the size of a target and the throwing distance. To solve the issue, the methods of testing the normal Gaussian distribution of data (Kolmogorov-Smirnov), the one way analysis of variance (Scheffe) and descriptive statistics have been used. The research confirmed that the determined conditions are fulfilled by the 10 m/0.7 m combination of the throwing distance and the size of a target for the men's category and the 6 m/0.7 m combination for the women's category.

Keywords: Accuracy, throw, dexterity test, throwing distance, target size.

INTRODUCTION

The skill to throw accurately represents an important part of the human dexterity package. These days, a throw at a target is missing its purpose within activities regarding livelihood or defence but it is still a useful item in a number of sport disciplines. Preschool children spontaneously manage a simple long distance throw and throw at a target at shoulder height, using available projectiles such as cones, snow balls, stones, etc. The youth of today, however, doesn't have an interest in the spontaneous development of a throw in their free time, within the framework of various activity games. This fact is highlighted in towns, where there is no suitable space capacity nor natural projectiles for throwing. Current education programmes (Primary school education programme 1996, the Framework education programme 1998) offer some free choice in selecting learning programmes in physical education at schools. However, learning a simple throw at a target is not being given enough attention at schools, although it represents a suitable emotional activity for improving the throw technique. One of the main reasons can be seen in the absence of a standardised test of the accuracy of a throw at a target, which would be able to cover and

subsequently check the development of a specific skill, which is the accuracy of a throw at a target.

The issue of constructing a test of the accuracy of a throw at a target was the main interest of many authors. There are tests in literature which use a horizontally oriented target (Broer, 1966; Ejem & Ambrož, 1969; Miller & Bartlett, 1992) or a vertically orientated target (Bayios & Boudolos, 1998; Brace, 1966; Malina, 1968; Merfield, 1969). Hits are scored by the authors either alternatively (Brace, 1966; Merfield, 1969), or the result of the test is often recorded as a deviation from the centre of the target by randomly allocating the area outlined with concentric circles of various diameters (Malina, 1968; Mecner, 1975). Another option is measuring deviations of both horizontal and vertical direction from the centre of the target (Malina, 1968; Mecner, 1975; Měkota & Blahuš, 1983), or by totalling points achieved by hitting sectors of a competitor's field, which are scored by various points' values (Broer, 1966; Měkota & Blahuš, 1983). The most common targets are the ones based on the principle of concentric circles. All of the above mentioned tests of the accuracy of a throw at a target are guided by specific requirements of a particular sport and therefore they can not be used at schools. In literature, we could have seen only two tests

of the accuracy of a throw at a target, which have been created for school youth (Boss, 2005; Mecner, 1975). Both tests are too complicated for routine use. We find that the most suitable method for evaluating the test of the accuracy of a throw at a target at schools is the dichotomy method, which means hit – no hit. The important thing is that the subject can check his/her own success at throwing.

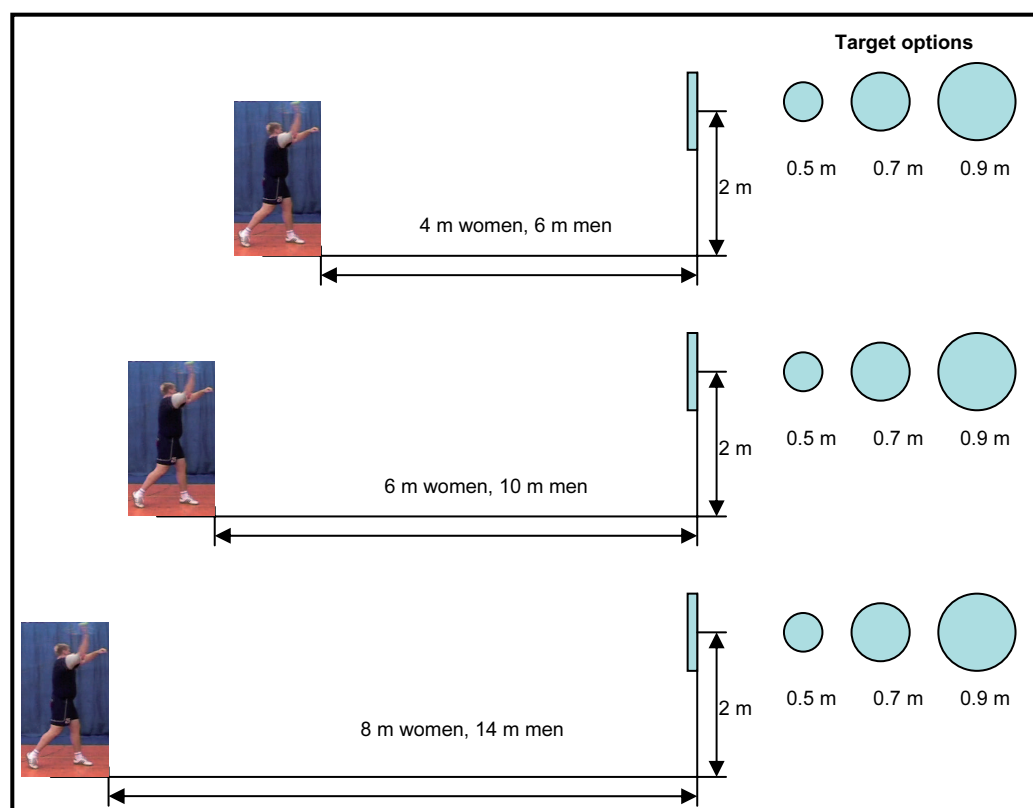
A successful hit of the target is guided by the optimal combination of the throwing angle and the throwing speed in relation to the throwing distance and the size of a target. The throwing subject must let out a projectile by optimal combination of force, which will be displayed in the throwing speed and angle, so that it hits the target. There are endless options of combinations of throwing parameters for reaching the target and it is almost impossible to reach two identical throwing parameters in two subsequent throws (Hubbard, 2000). The skill of accuracy of a throw is closely linked with the issue of controlling movement and the coordination of the eye – head – hand (Schmidt & Lee, 2005). A successful hit of a target can be theoretically achieved by limited combinations of throwing parameters. The throwing subject can use a combination of a fast throwing speed

and a small throwing angle or a slower throwing speed with a large throwing angle. In both cases, a successful hit of a target will be achieved providing that their combination is correct (Barttlet, 2000). The relationship between the speed and accuracy is known as a compromise of speed and accuracy (Schmidt & Lee, 2005). With the growing speed of a movement the accuracy drops and visa versa (Fitts, 1954). Slower throwing speed and larger angle lead to better results in tests of accuracy of a throw at a target. Bancazio (1992) states Barttlet (2000) confirms the existence of a specific throwing angle heading towards the centre of a target and its related optimal throwing speed. Simultaneously, deviation limits are mentioned for speed and for angle regarding this pair of figures, so that successful hit of a target is achieved. The deviation limits can grow with the size of a target.

The main issue in working out the test of the accuracy of a throw at a target is determining the optimal size of a target and the throwing distance for a targeted group of people. The aim of the study is to optimise the size of a target and the throwing distance for a selected group of university male and female students.

Fig. 1

Schematic representation of the combination of the size of a diameter of a target and the throwing distance



METHOD

Basic criteria for optimising the size of a target and the throwing distance for a test of the accuracy of a throw at a target

Optimisation of the size of a target and the distance is guided by the following conditions:

- The tested group will achieve an average amount of successful hits of the target out of the total amount of throws, in a specific combination of the size of a target and the throwing distance.
- The tested group will have a standard distribution of the count of successful hits of the target, in a specific combination of the size of a target and the throwing distance.

Research group

The research group was made up of 79 men and 71 women, students of the first year at the Ostrava University in Ostrava, the Physical Education and Recreation study fields. The group included only those persons who successfully fulfilled the conditions for being accepted in the above mentioned study fields. We assume the students to have a relatively high skill level of a simple throw above shoulder height. The age of the tested persons ranged from 20 to 23 years.

The process and organisation of measuring

The experiment included a combination of 3 different distances (men 6, 10 and 14 m and women 4, 6 and 8 m) and the size of a target (0.5, 0.7 and 0.9 m), altogether 9 combinations.

The tested persons (TP) had, in each of the nine combinations of the size of a target and the throwing distance, 10 throws, which means that each TP performed altogether 90 throws, in three combinations of the size of a target and at three distances from the target. Prior to the commencement of measuring, each TP carried out 10 practise throws with the combination of a target and distance at which he or she started throwing. With regard to the timely and organisational intensity, we selected the following procedure of measuring. The TPs threw from one distance at three different sizes of targets, always from the smallest diameter to the biggest, and then they moved to another distance from where they again threw at three different sizes of targets. The tested persons threw a tennis ball whilst standing, from a marked throwing point, using a preferred arm to throw above shoulder height at a vertical round target (Fig. 1). The final score of the experiment is then made up of the count of successful hits of the target, out of ten throws, achieved in all of the nine combinations of the throwing distance and the size of a target.

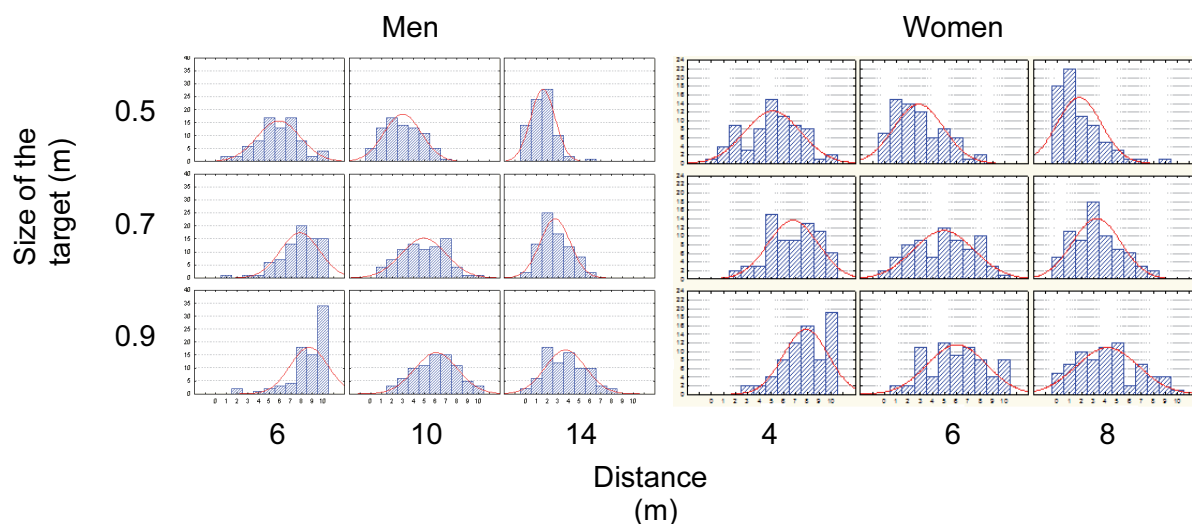
To eliminate the training of tested persons, the method of a Latin square was used. The tested persons were split into threes. Each trio of TPs started to throw from a different throwing distance at all three sizes of targets.

Statistical methods

The following methods were used to solve the issue: normal Gaussian distribution of data was tested by the Kolmogorov-Smirnov test, the one way ANOVA

Fig. 2

Histograms showing the count of distribution of successful hits in different combinations of the throwing distance and the size of a target, men (n = 79), women (n = 71)



(Analysis of variance) (Scheffe) and descriptive statistics. The results were processed with the help of a statistic programme SPSS.

RESULTS

Optimisation of the size of a target and the throwing distance

The aim of the study is to find a suitable combination of the throwing distance and the size of a target, which will suit the determined conditions.

The test score of the experiment was represented by the number of successful hits of the target out of ten throws in a specific combination of the size of a target and the throwing distance.

The condition of the normality of distribution of experimental data was verified within the experiment. The Kolmogorov-Smirnov test confirmed the normality of distribution of the experimental data in all combinations of the size of the target and the distance, except from the 6 m/0.9 m combination in the men's category and with the exception of the 4 m/0.9 m and 8 m/0.5 m combinations in the women's category. Visual information on the distribution of the count of experimental data is given in the histograms shown in Fig. 2.

All nine combinations of the size of the target and the distance were subject to the one way analysis of

variance. Statistically important differences between variations regarding the group of men and of women were found by the analysis of variance (TABLE 1a) and between the averages of successful hits using individual combinations of the size of the target and the throwing distance in men (TABLE 1b) and women (TABLE 1c).

One way analysis of variance (Scheffe) divided the average scores of successful hits of the target using individual combinations of the throwing distance and size of a target into 5 homogeneous groups in the men's category. The combination of the size of the target and the throwing distance in the homogeneous group 3, resembles the condition for achieving the average score of the count of successful hits of the target. The combinations are 10 m/0.7 m and 6 m/0.5 m. Out of the two, the 10 m/0.7 m combination fulfils the basic conditions best.

One Way Analysis (Scheffe) similarly divided the individual combinations of throwing distances and target sizes into 6 homogeneous groups in the women's category. In this category, the condition that the tested group will achieve an average score of the count of successful hits resembles the combination of the target size and the throwing distance in the homogeneous group 3, which represents combinations 8 m/0.9 m, 6 m/0.7 m and 4 m/0.5 m. Out of this group, the combination 6 m/0.7 m suits the above stated condition best.

TABLE 1a

One Way Analysis of Variance - variance analysis (Scheffe) men (n = 79), women (n = 71)

Men								Women								
Throwing distance / Size of target		s	Homogeneous groups					Throwing distance / Size of target		s	Homogeneous groups					
	$\bar{x}$		1	2	3	4	5		$\bar{x}$		1	2	3	4	5	6
14/0.5	1.36	2.00	x					8/0.5	1.80	1.76	x					
14/0.7	2.70	1.81		x				6/0.5	2.84	1.91	x	x				
10/0.5	2.94	1.75		x				8/0.7	3.25	2.55	x	x				
14/0.9	3.65	1.72		x				8/0.9	4.14	1.72		x	x			
10/0.7	4.88	2.06			x			6/0.7	4.90	2.47			x	x		
6/0.5	5.82	1.98			x	x		4/0.5	5.07	2.30			x	x		
10/0.9	6.03	1.13				x		6/0.9	6.00	2.44				x	x	
6/0.7	7.79	1.39					x	4/0.7	6.76	2.11					x	x
6/0.9	8.64	1.86					x	4/0.9	7.83	1.84						x

Legend:

Combination of distance (m)/target (m),

$\bar{x}$ - diameter,

s - standard deviation,

x - homogeneous groups.

TABLE 1b

Variations between average scores of successful hits, men (n = 79), one way analysis of variance (Scheffe)

Throwing distance / Target size	Precise scores of variations of averages for various throws								
	14/0.5	14/0.7	10/0.5	14/0.9	10/0.7	6/0.5	10/0.9	6/0.7	6/0.9
14/0.5	–	1.34*	1.58*	2.29*	3.52*	4.46*	4.67*	6.43*	7.28*
14/0.7		–	0.24	0.95	2.18*	3.12*	3.33*	5.09*	5.97*
10/0.5			–	0.71	1.94*	2.88*	3.09*	4.85*	5.89*
14/0.9				–	1.23*	2.17*	2.38*	4.14*	4.99*
10/0.7					–	0.94	1.15*	2.91*	3.76*
6/0.5						–	0.21	1.97*	2.82*
10/0.9							–	1.76*	2.61*
6/0.7								–	0.85
6/0.9									–

Legend:

Throwing distance (m)/target size (m),

*p < .05,

the stated figures represent precise scores of variations of averages.

TABLE 1c

Variations between average scores of successful hits, women (n = 71), one way analysis of variation (Scheffe)

Throwing distance / Target size	Precise scores of variations of averages for various throws								
	8/0.5	6/0.5	8/0.7	8/0.9	6/0.7	4/0.5	6/0.9	4/0.7	4/0.9
8/0.5	–	1.04	1.45	2.34*	3.10*	3.27*	4.20*	4.96*	6.03*
6/0.5		–	0.41	1.30	2.06*	2.23*	3.16*	3.92*	4.99*
8/0.7			–	0.89	1.65*	1.82*	2.75*	3.51*	4.58*
8/0.9				–	0.76	0.93	1.86*	2.62*	3.69*
6/0.7					–	0.17	1.10	1.86*	2.93*
4/0.5						–	0.93	1.69*	2.76*
6/0.9							–	0.76	1.83*
4/0.7								–	1.07
4/0.9									–

Legend:

Throwing distance (m)/target size (m),

*p < .05,

the stated figures represent precise scores of variations of averages.

DISCUSSION

The available dexterity tests, covering the skill of an accurate throw, stem from a particular sports event (Bayios & Boudolos, 1998; Malina, 1968; Miller, 1992). Non specific tests of accuracy determined for school children are presented by (Böss, 2005; Měkota & Blahuš, 1983). What method was used by the authors of the above stated tests, to arrive at the used throwing distance and the size of a target is not evident. We assume that their reasoning was based on the practical

needs of sport divisions or on the personal opinions of the authors. In the submitted contribution we try to show the exact method of solving the basic issue in constructing a test of accuracy of a throw at a target, which means optimisation of the throwing distance and the size of a target.

Optimisation of the size of a target and the throwing distance consisted in finding such a combination of the size of a target and a distance, which would suit the two above stated conditions, which means that the tested group will achieve an average count of successful hits

out of all throws and simultaneously the final score of the given group will suit the condition of the normal distribution of the experimental data.

Both of the set out conditions ensure the test of the accuracy of a throw at a target having the option of using parametric statistical methods in other statistical analyses.

A basic requirement was set out during the early considerations of constructing a test of the accuracy of a throw at a target, which was for the test to cover the whole range of the current level of skill of throw accuracy within a tested group. The whole range of the level of skill of throw accuracy can be covered, when the achieved results for a specific combination of the throwing distance and the size of a target have a normal distribution and the medium score is around the middle of the variation span of the tested group. The consideration is based on the practical experimental situation of extreme combinations of the throwing distance and the size of a target. A long throwing distance with a small size target or a short throwing distance combined with a large target will result in a shift of the count of successful hits of the target for individual tested persons towards extreme scores. In the first case, it will be extremely low scores of the count of successful hits of the target and vice versa, in the second case it will be towards the high scores of successful hits (see histograms of counts, Fig. 2). The test of the accuracy of a throw at a target was constructed using a sample of students of the Physical Education and Recreation fields. Following the verification of other criteria, which the test must fulfil (reliability, validity) it will be modified for school education use. There is a presumption that with the age of school children descending, the importance of the throw technique and the force capacity of the throwers will grow. These important factors may have a significant influence on the achieved results of the test of the accuracy of a throw at a target. Within the next stage of the research, we shall adapt individual combinations of the throwing distance and the size of a target, so that they are suitable for a particular age group of school children. The presented contribution suggests a specific approach for constructing a test of accuracy of a throw at a target. We assume that the test of the accuracy of a throw at a target will be a suitable and easily available test, which will be used not only for the diagnostics of the skill of the accuracy of a throw, but also as a tool for developing the skill of throwing. The easy quantification of the test result of the accuracy of a throw at a target by the actual thrower has an important motivational effect. The test fulfils the basic condition of safety, as throwing a tennis ball minimises the risk of injury.

CONCLUSION

Optimisation of the size of a target and the throwing distance for the test of the accuracy of a throw at a target for the adult category (university students), is conditioned by the fulfilment of two conditions:

- Our research confirmed that the condition of achieving a final score as an average of the total count of throws is, for the men's category, fulfilled by the combination of the throwing distance and the size of a target of 10 m/0.7 m and the 6 m/0.7 m combination for the women's category.
- The research confirmed that the condition of the normal Gaussian distribution of experimental data is fulfilled in both categories by most tested combinations of the distance and the size of a target, except for extreme situations (the combination 6 m/0.9 m for men and the combinations 4 m/0.9 m and 8 m/0.5 m for women).
- While respecting the determined conditions, for the test of the accuracy of a throw at a target for adults, we suggest using the 10 m/0.7 m combination of the throwing distance and the size of a target for men and 6 m/0.7 m for women.

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OPTIMALIZACE VELIKOSTI TERČE A ODHODOVÉ VZDÁLENOSTI PŘI HODU NA CÍL PRO DOSPĚLÉ OSOBY (Souhrn anglického textu)

Cílem studie je optimalizovat odhodovou vzdálenost a velikost terče jako východisko ke konstrukci testu přesnosti hodu na cíl tenisovým míčem. Optimální kombinace musí splňovat dvě podmínky – testovaný soubor dosáhne u konkrétní kombinace velikosti terče a odhodové vzdálenosti průměrné hodnoty počtu úspěšných zásahů terče z celkového počtu hodů a bude splňovat podmínku normálního rozdělení. Zkoumaný soubor tvořilo 79 mužů a 71 žen, studentů prvního ročníku oborů tělesná výchova a rekreologie Ostravské univerzity v Ostravě. Pro experiment byly zvoleny pro

obě kategorie tři velikosti terče (0,5; 0,7; 0,9 m) a tři odhodové vzdálenosti (6, 10, 14 m pro muže a 4, 6, 8 m pro ženy) – celkem devět kombinací. Skóre experimentu tvoří počet úspěšných zásahů terče z desíti hodů v každé kombinaci velikosti terče a odhodové vzdálenosti. Pro řešení problematiky byly použity metody testování normality rozložení experimentálních dat (Kolmogorov-Smirnov), jednofaktorová analýza rozptylu (Scheffe) a základní statistické charakteristiky. Výzkum prokázal, že stanovené podmínky splňuje v kategorii mužů kombinace odhodové vzdálenosti a velikosti terče 10 m/0,7 m a v kategorii žen kombinace 6 m/0,7 m.

Klíčová slova: hod, přesnost, motorický test, odhodová vzdálenost, velikost terče.

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