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Original Article

Comparison between rotational and glide techniques in shot put based on the performance analysis of competitions

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Abstract:
In shot put, both the glide and rotational techniques are used; however, the superiority of one technique over the other remains unclear. This study aimed to determine relative strengths and weaknesses of the glide and rotational techniques in shot put based on the analysis of competitive performance. Competition results for 176 male shot putters from international-level competitions held between 2001 and 2022 were collected. Their record, season's best record (SB), the ratio of the record in the competition to season's best record (%SB), and the rate of foul attempts were compared between the two techniques. The results showed that the mean %SB was higher for the glide technique compared to the rotational technique (glide: 97.31 ± 2.24%, rotational: 96.42 ± 2.28%, d = 0.39, p = 0.024). This indicates that the glide technique is better in maintaining a constant throwing action between each round. However, there was no difference in the %SB of the best record between the two techniques (rotational: 97.78 ± 2.58%, glide: 98.42 ± 2.55%, d = 0.25, p = 0.149). Additionally, the frequency of use of the throwing techniques (rotational: n = 130, glide: n = 46), the best record (rotational: 20.96 ± 0.87 m, glide: 20.67 ± 0.70 m, d = 0.35, p = 0.046) and SB (rotational: 21.44 ± 0.69 m, glide: 21.00 ± 0.48 m, d = 0.43, p < 0.001) were significantly higher for the rotational technique, and there was no significant difference in the rate of foul attempts. These findings show that the rotational technique is superior at achieving a higher performance, especially for recent international-level male shot putters.
Key Words: **coexisting techniques, competition results, rate of foul attempts, characteristics of technique**

Introduction

In the shot put, the throwing distance is determined by release parameters, which include release height, release angle, and release velocity (Hubbard, de Mestre, & Scott, 2001; Saračević, Atiković, Štuhec, & Čuk, 2018; Zatsiorsky, Lanka, & Shalmanov, 1981). On these parameters, release velocity has the greatest impact on the throwing distance (Hay, 1993; Kumar, Murali, & MR, 2016; Kusuma, 2021; Lanka, 2000; Lipovšek, Škof, Štuhec, & Čoh, 2011; Luhtanen, Blomqvbist, & Vänttinen, 1997; Zatsiorsky et al., 1981). Shot put motion takes place within a circle with a diameter of 2.135 meters. The motion can be divided into a preparatory phase for body acceleration and a delivery phase to accelerate the shot for release. There are two techniques used in the shot put—the glide and the rotational technique.

While the glide technique, created by Parry O'Brien in the 1950s, has been a dominant throw method, the rotational technique gained popularity after Alexander Baryshnikov became the first person to throw more than 22 meters with this technique in 1976. Considering that the Fosbury flop remained the only technique in the high jump, it is quite unusual that the two techniques in the shot put coexist to this day (Judge, 2015). In recent years, the rotational technique has become the mainstream technique, particularly for male athletes at the international level (Babbit & Saatara, 2014; Dinsdale, Thomas, Bissas, & Merlino, 2017; Hatase & Takanashi, 2022; Salinero & Del Coso, 2021; Schofield, Cronin, Macadam, & Hebert-Losier, 2022; Thomas, Dinsdale, Bissas, & Merlino, 2019). However, the glide technique is still widely used by elite female athletes, while both male and female athletes use the technique at the youth and junior levels, as well as at the national championship level.

Biomechanical comparisons and performance analysis have been used to clarify the characteristics and superiority of the glide and rotational techniques in the shot put. Biomechanical analysis has shown that the glide technique is characterized by a low load and the ability to perform a push-off motion with a straight trajectory from a balanced stance during the final delivery phase (Coh & Stuhec, 2005; Gutiérrez-Davila, Rojas, Campos, Gámez, & Encarnación, 2009). In contrast, the rotational technique is characterized by a long acceleration path length, a high vertical component of the ground reaction force, and a high angular velocity of rotation around the long axis of the shoulder in the final delivery phase, but a large centripetal force makes it difficult to stabilize the throwing direction (Bartonietz, 1994; Kato, Maeda, Mizushima, & Maeda, 2022; Lanka, 2000; Ohyama-Byun et

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al., 2008; Zatsiorsky et al., 1981). Salinero & Del Cosa (2021) conducted a performance analysis by collecting and examining data on the percentage of throwing techniques used, records, and the percentage of throwing techniques adopted by the male and female medalists at the World Athletics Championships from 2001 to 2019. They found that the rotational technique is becoming the dominant technique for men, while the glide technique remains the most common technique for women, but the number of athletes adopting the rotational technique is increasing. Additionally, previous research on the evolution of shot put has shown that deliberate adoption of the rotational technique could potentially present an opportunity for improving shot put records (Hatase & Takanashi, 2022). However, there is no significant difference in competition results or frequency of fouls between the two techniques, and no conclusive evidence has been presented to clarify the superiority of one technique over the other (Salinero & Del Coso, 2021).

Biomechanical studies suggest that the rotational technique may be more challenging than the glide technique, particularly with respect to executing the push-off motion of the shot. As such, the glide technique is characterized by a simple movement, whereas the rotational technique is complex and demands a high level of balance and body control ability (Pagel & Pagel, 2003). Therefore, it is suggested that the glide technique can perform more constant performance in a competition than the rotational technique. To compare the superiority of one over the other, it is necessary to assess their performance outcomes in competition.

Therefore, the purpose of this study was to compare the glide and rotational techniques and determine their relative strengths and weaknesses, based on the performance results obtained from men's international competitions.

Methods

Participants

A total of 176 male shot putters comprising the top 12 in each event, who competed in the finals at 12 World Championships in Athletics or World Athletics Championships and 4 Summer Olympic Games held between 2001 and 2022, were included in the study. Each participant was considered as a single entity for evaluation even if the same athlete competed in multiple competitions as the season's best records were used as the basis for evaluation.

Data collection

The participant's record, ranking position in the competition, and the number of fouls for each round were obtained from the results of each competition posted on the website of World Athletics ("World Athletics," 2023). The season's best record (SB), which was the highest record achieved from January 1st of the same year as the competition under analysis to just before the competition, was obtained from each participant's profile in the World Athletics' website ("World Athletics," 2023). The performance rate (%SB) was calculated as the ratio of the record in the competition to SB of the participant. Athletes who had "No marks" or "Disqualified" in the competition at the time of website reference were excluded. Similarly, athletes who had "No record" or "DSQ" in the competition were also excluded. The throwing technique of the participants was determined by watching the video of the competition and the images of the participants. Athletes whose throwing technique could not be determined were excluded from the study.

Statistical analysis

Results were presented as mean ± standard deviations. Record, SB, and %SB for the glide and rotational techniques were compared using Welch's test, and the effect size (Cohen's d) was calculated to indicate the magnitude of the difference. Pearson's product-rate correlation coefficient was used to examine the relationship between SB, record, and %SB, while Spearman's rank correlation coefficient was used to examine the relationship between ranking position and record, SB, and %SB. A two-way ANOVA was used to analyze differences of the record and %SB between the techniques and rounds, and multiple comparisons were made using the Bonferroni test when the interaction was significant. A simple main effect was tested when the interaction was not significant. The percentage of fouls among techniques was calculated by including valid attempts and compared using the χ^2 test. All tests were conducted using SPSS Statistics 27.0 (IBM Inc., Japan), and the statistical significance level was set at 5%.

Results

Fig. 1 and Fig. 2 show the frequency of throwing techniques used in the competitions and used by the ranking positions achieved by the participants, respectively. Table 1 details the frequency of throwing techniques in the competitions by the ranking positions. Out of the 176 participants, 130 used rotational throwing techniques and 46 used glide techniques. Over the years, the frequency of shot putters using the rotational technique increased, reaching all from 2019. Table 2 shows data on SB, record, and %SB. SB, records for the 1st ,4th and 5th rounds, and the best record were significantly higher for the rotational than for the glide technique (d = 0.67, p < 0.001; d = 0.38, p = 0.049; d = 0.54, p = 0.040; d = 0.56, p = 0.012; d = 0.35, p = 0.046, respectively), while %SB for the 1st and 2nd rounds and mean %SB of all rounds were significantly higher for the glide than for the rotational technique (d = 0.40, p = 0.040; d = 0.44, p = 0.037; d = 0.39, p = 0.024, respectively).

Fig. 1 Frequency of throwing techniques used in competition.

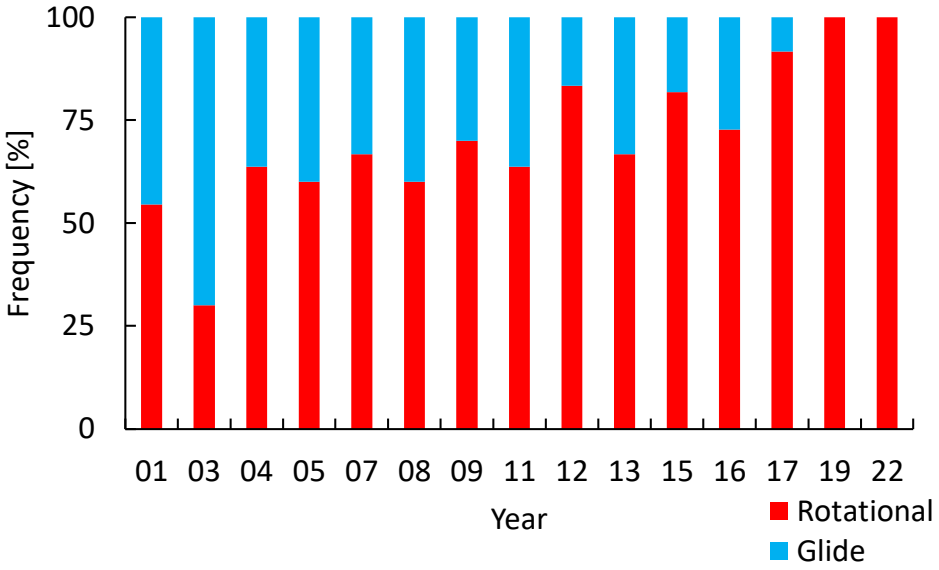

Fig. 2 Frequency of throwing techniques by ranking position in competition.

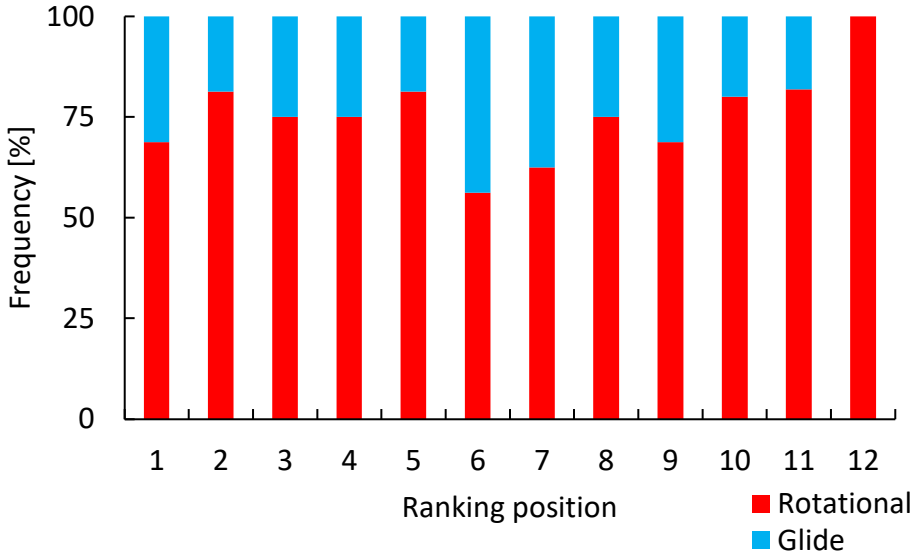

Table 1 Frequency of throwing techniques in competition by ranking positions.

Year / Ranking	01	03	04	05	07	08	09	11	12	13	15	16	17	19	21	22
1st	R	G	R	R	R	G	R	G	G	G	R	R	R	R	R	R
2nd	R	R	R	R	R	R	G	R	G	R	G	R	R	R	R	R
3rd	R	G	G	G	R	R	G	R	R	R	R	R	R	R	R	R
4th	G	R	G	R	G	R	R	R	R	R	R	G	R	R	R	R
5th	R	G	R	R	R	G	R	R	R	G	R	R	R	R	R	R
6th	G	G	R	G	G	R	R	R	R	G	G	G	R	R	R	R
7th	G	G	G	G	R	G	R	R	R	R	R	G	R	R	R	R
8th	G	R	R	G	R	R	R	G	R	G	R	R	R	R	R	R
9th	G	G	R	R	G	R	G	G	R	R	R	R	R	R	R	R
10th	R	G	R	R	-	G	R	R	R	R	R	R	G	R	R	R
11th	R	-	G	-	-	-	-	G	R	R	R	R	R	R	R	R
12th		-	-	-	-	-	-	-	R	R	-	-	R	R	R	R

R: Rotational G: Glide

Table 2 Comparison of SB, record, and %SB between throwing techniques.

	Overall	Rotational	Glide	Difference (95 % CIs)	*d*
Number of participants	176	130	46		
SB [m]	21.32 ± 0.67	21.44 ± 0.69*	21.00 ± 0.48	0.43 (0.25 to 0.62)	0.67
Record [m]					
1st round	20.54 ± 0.81	20.61 ± 0.84*	20.31 ± 0.70	0.31 (0.00 to 0.61)	0.38
2nd round	20.69 ± 0.73	20.73 ± 0.75	20.59 ± 0.67	0.14 (-0.17 to 0.44)	0.19
3rd round	20.67 ± 0.75	20.72 ± 0.79	20.52 ± 0.62	0.21 (-0.10 to 0.51)	0.28
4th round	20.98 ± 0.70	21.09 ± 0.73*	20.72 ± 0.55	0.37 (0.02 to 0.72)	0.54
5th round	20.94 ± 0.84	21.07 ± 0.89*	20.61 ± 0.61	0.46 (0.10 to 0.82)	0.56
6th round	21.08 ± 0.82	21.20 ± 0.88	20.79 ± 0.60	0.41 (-0.05 to 0.86)	0.50
Best record	20.88 ± 0.83	20.96 ± 0.87*	20.67 ± 0.70	0.29 (0.01 to 0.57)	0.35
Mean	20.61 ± 0.75	20.67 ± 0.78	20.44 ± 0.62	0.23 (-0.02 to 0.48)	0.31
%SB [%]					
1st round	96.34 ± 2.73	96.09 ± 2.66	97.16 ± 2.82*	1.07 (2.09 to -0.05)	0.40
2nd round	96.69 ± 2.70	96.40 ± 2.75	97.58 ± 2.38*	-1.18 (-2.29 to -0.07)	0.44
3rd round	96.79 ± 2.42	96.55 ± 2.38	97.42 ± 2.47	-0.87 (-1.86 to 0.12)	0.36
4th round	97.48 ± 2.30	97.17 ± 2.22	98.27 ± 2.35	-1.10 (-2.27 to 0.07)	0.49
5th round	97.27 ± 2.58	97.06 ± 2.85	97.83 ± 1.60	-0.77 (-2.09 to 0.54)	0.30
6th round	97.62 ± 2.19	97.44 ± 2.29	98.04 ± 1.93	-0.60 (-1.84 to 0.65)	0.27
Best record	97.94 ± 2.58	97.78 ± 2.58	98.42 ± 2.55	-0.64 (-1.52 to 0.23)	0.25
Mean	96.65 ± 2.30	96.42 ± 2.28	97.31 ± 2.24*	-0.89 (-1.67 to -0.12)	0.39

*: $p < 0.05$

Table 3 shows the correlation coefficients of records and %SB with SB. Significant positive correlations were found between SB and the records of 1st to 6th rounds, the best record, and the mean record of all rounds for the overall (r = 0.64 to 0.82, $p < 0.001$), rotational (r = 0.65 to 0.82, $p < 0.001$), and glide techniques (r = 0.53 to 0.73, p = 0.010; $p < 0.001$). Significant negative correlations (r = -0.30 to -0.16, p = 0.001 to 0.047; $p < 0.001$) were found between SB and %SB on the 2nd and 4th rounds, and the mean %SB on all rounds for the overall. Significant negative correlations (r = -0.27, p = 0.001) were found between SB and %SB on the 2nd round in the rotational technique. No significant correlation was found between SB and any variables for the glide technique.

Table 3 Correlation coefficients of record and %SB with SB.

	Overall	Rotational	Glide
	r (95 % CIs)	*r* (95 % CIs)	*r* (95 % CIs)
Record			
1st round	0.71 (0.62 to 0.78)*	0.74 (0.64 to 0.81)*	0.54 (0.25 to 0.73)*
2nd round	0.64 (0.52 to 0.74)*	0.65 (0.51 to 0.75)*	0.66 (0.39 to 0.82)*
3rd round	0.74 (0.64 to 0.81)*	0.77 (0.67 to 0.84)*	0.57 (0.27 to 0.76)*
4th round	0.74 (0.61 to 0.83)*	0.77 (0.62 to 0.86)*	0.53 (0.11 to 0.78)*
5th round	0.75 (0.63 to 0.83)*	0.72 (0.55 to 0.82)*	0.83 (0.62 to 0.93)*
6th round	0.82 (0.70 to 0.88)*	0.82 (0.69 to 0.90)*	0.73 (0.38 to 0.89)*
Best record	0.75 (0.68 to 0.81)*	0.77 (0.69 to 0.83)*	0.64 (0.43 to 0.79)*
Mean	0.76 (0.69 to 0.82)*	0.78 (0.70 to 0.84)*	0.66 (0.45 to 0.80)*
%SB			
1st round	-0.15 (-0.31 to 0.01)	-0.12 (-0.30 to 0.07)	-0.05 (-0.37 to 0.29)
2nd round	-0.27 (-0.43 to -0.10)*	-0.27 (-0.45 to -0.07)*	-0.05 (-0.40 to 0.32)
3rd round	-0.19 (-0.36 to -0.01)*	-0.15 (-0.35 to 0.06)	-0.18 (-0.49 to 0.19)
4th round	-0.30 (-0.50 to -0.08)*	-0.20 (-0.45 to 0.08)	-0.38 (-0.69 to 0.07)
5th round	-0.10 (-0.32 to 0.13)	-0.07 (-0.33 to 0.20)	0.12 (-0.33 to 0.53)
6th round	-0.01 (-0.27 to 0.24)	0.10 (-0.22 to 0.39)	-0.19 (-0.60 to 0.31)
Best record	-0.05 (-0.20 to 0.10)	-0.02 (-0.19 to 0.16)	-0.04 (-0.33 to 0.26)
Mean	-0.16 (-0.30 to -0.01)*	-0.12 (-0.29 to 0.05)	-0.12 (-0.40 to 0.18)

*: $p < 0.05$

Fig. 3, 4 and 5 show the relationships of SB, the best record, and %SB of the best record with the ranking position in competition. Table 4 shows the rank correlation coefficients of records and %SB with the ranking position in competition. For the overall, rotational, and glide techniques, SB, record in 1st to 6th rounds, the best record, and mean record of all rounds were significantly negatively correlated with the ranking position (ρ = -0.89 to -0.51, p = 0.001 to 0.003; $p < 0.001$). For the overall, the %SB of 1st to 6th rounds, %SB of the best record, and the mean %SB of all rounds were significantly negatively correlated with the ranking position (ρ = -0.60 to -0.23, p = 0.001 to 0.047; $p < 0.001$). For the rotational technique, %SB of the 1st to 3rd rounds, %SB of

the best record, and mean %SB of all rounds were significantly negatively correlated with the ranking position (ρ = -0.58 to -0.27, p = 0.003 to 0.008; $p < 0.001$). Similarly, for the glide technique, %SB for 1st to 3rd rounds, %SB for the best record, and mean %SB for all rounds were significantly negatively correlated with the ranking position (ρ = -0.71 to -0.33, p = 0.002 to 0.048; $p < 0.001$).

Fig. 3 Relationship between SB and ranking position in competition.

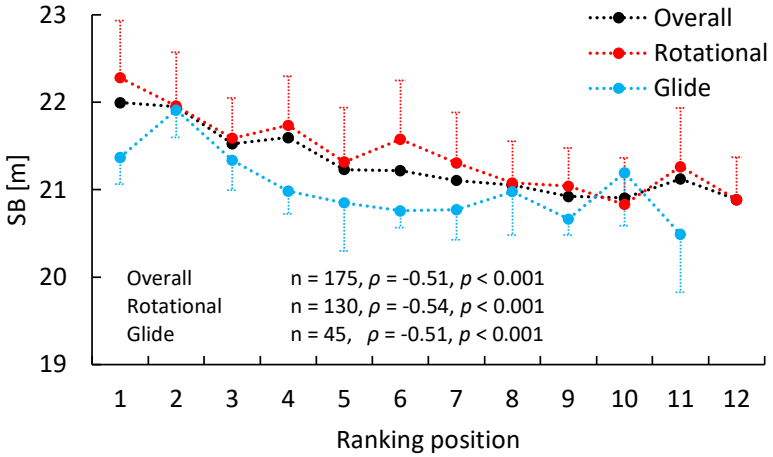

Fig. 4 Relationship between the best record and ranking position in competition.

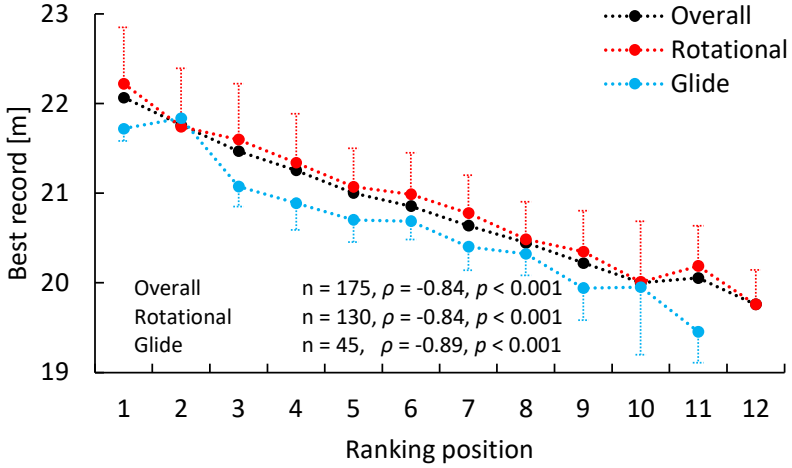

Fig. 5 Relationship between %SB of the best record and ranking position in competition

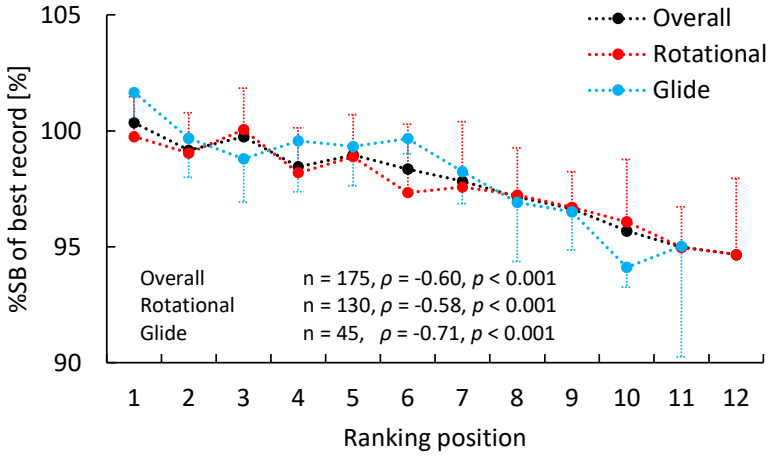

Fig. 6 shows the comparison of records between throwing techniques by rounds. A two-way ANOVA revealed no interaction between round and throwing technique in records ($F = 0.48$, $p = 0.793$). Simple main effects were observed for the 1st and 5th round records ($F = 4.30$, $p = 0.038$; $F = 5.50$, $p = 0.019$, respectively), with both rotational records were significantly higher than those for the glide. A significant simple main effect was found between rounds for the rotational technique ($F = 6.67$, $p < 0.001$), with records for the 4th and 5th rounds were significantly higher than those for 1st round, and the record for the 6th round were significantly higher than those for the 1st, 2nd, and 3rd rounds. However, there was no significant simple main effect on records for the glide ($F = 1.34$, $p = 0.246$), and there were no significant differences in records between rounds.

Fig. 6 Comparison of records between throwing techniques by rounds.

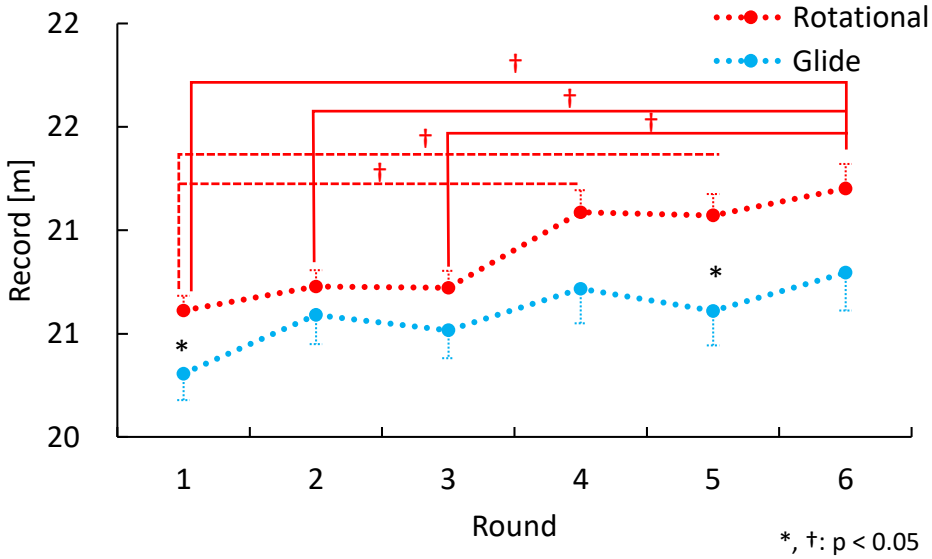

Fig. 7 shows the comparison of %SBs between throwing techniques by rounds. A two-way ANOVA indicated that there was no interaction between round and throwing technique in %SB ($F = 0.13$, $p = 0.936$). However, a significant simple main effect was found in %SB for the 1st and 5th rounds ($F = 4.94$, $p = 0.027$; $F = 4.96$, $p = 0.026$, respectively), with the glide yielding significantly higher than the rotational technique. Additionally, a significant simple main effect was found between each round of the rotational technique ($F = 2.86$, $p = 0.015$), with the %SB of the 6th round was significantly higher than that of the 1st round. There was no significant simple main effect between rounds in the glide ($F = 0.69$, $p = 0.635$), and there was no significant difference in %SBs between rounds.

Fig. 7 Comparison of %SBs between throwing techniques by rounds.

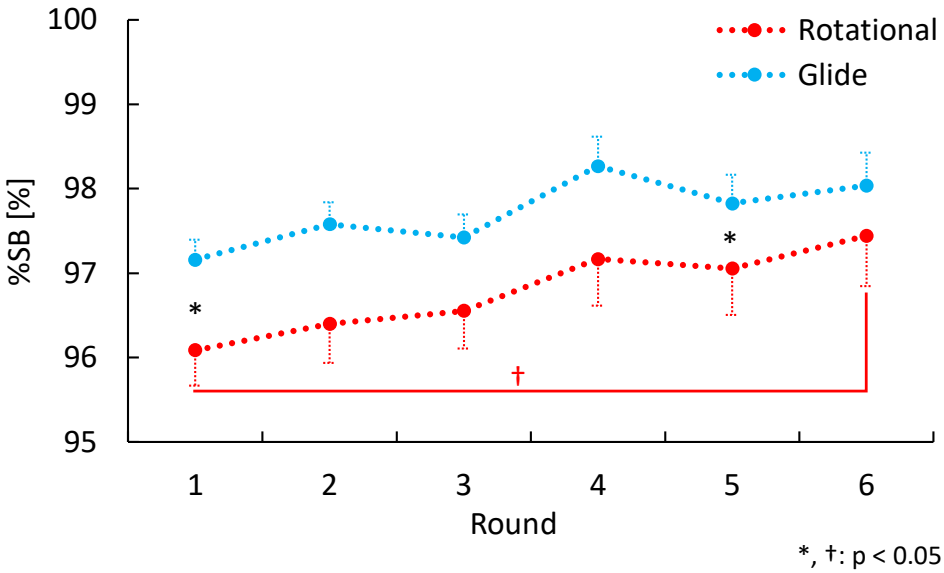

Table 5 shows the measured values and percentages of valid and foul attempts for each round. Results of the χ^2 test revealed that the percentage of foul attempts during the glide technique was significantly higher than during the rotational technique on the 4th round ($\chi^2 = 4.86$, $p = 0.027$). However, no significant difference was found in the percentage between the rotational and glide techniques for the other rounds.

Table 5 Frequencies and differences of foul attempts between the throwing techniques for each round.

	Rotational		Glide		χ^2
	Valid	Foul	Valid	Foul	
All rounds	439	214	158	70	0.33
1st round	109	21	41	4	1.44
2nd round	89	41	33	12	0.38
3rd round	88	42	29	16	0.16
4th round	58	28	15	18	4.86 *
5th round	53	33	23	10	0.67
6th round	42	43	17	16	0.04

*: $p < 0.05$

Discussion

The objective of this study was to compare the performance results of men's international shot put competitions to determine relative strengths and weaknesses of the shot put throwing techniques. The study collected the results of 176 athletes and compared the performance results between the different throwing techniques. It also examined the relationship between the competition results and compared the results between rounds. In general, the findings showed that the glide technique had a significantly higher %SB compared to the rotational technique, while the rotational technique had a higher frequency of use, best record, and SB. However, there was no significant difference in the rate of foul attempts.

The data of frequency of throwing techniques showed that over 70% of total participants used the rotational technique, which supports that the rotational technique is the mainstream technique for male athletes at the international level (Dinsdale et al., 2017; Salinero & Del Coso, 2021; Schofield et al., 2022; Thomas et al., 2019). Based on the comparison of variables, the rotational technique had significantly higher SB and best record than the glide technique. This means that not only is the rotational technique the mainstream technique, but it also allows male athletes to achieve higher performance at the international level. However, the glide technique had significantly higher %SB than the rotational technique for the mean of all rounds throws. The release velocity, which has the highest impact on the throwing distance, is mainly increased during the delivery phase for both glide and rotational techniques (Luhtanen et al., 1997; Marhold, 1974). Therefore, the technical success or failure of delivery phase is likely to impact the performance result. The delivery phase of the glide technique allows for a push-off motion with a straight trajectory from a balanced stance (Coh & Stuhec, 2005; Gutiérrez-Davila et al., 2009). This allows shot putters who use the glide technique to accelerate the shot with a constant delivery action between each round and achieve a high %SBs. In contrast, rotational technique has difficulty stabilizing the throwing direction due to its large centripetal motion (Lanka, 2000). This could have resulted in variations in motion during the delivery phase and in throwing direction between attempts, and changes in shot acceleration could have led to fluctuations in the %SBs.

The correlation and rank correlation analysis showed similar results between the techniques. The result of a two-way ANOVA showed that the rotational technique increased records with each round, and the %SB of 6th round was significantly higher than the 1st round. This suggests that shot putters using the rotational technique can achieve higher rankings in international competitions by marking higher record in a maximum of six rounds, especially achieving a high %SB in the final round. Since the final competition ranking for the shot put is determined by the best record, it is not a problem that the records and %SB vary between rounds with the rotational technique. Rather, this technique proves to be a consistent and high performing throw over six rounds in male international-level athletes.

Based on the results of the %SB comparisons and the identified characteristics of the delivery phases of both throwing techniques, it was hypothesized that the rotational technique would result in a higher percentage of foul attempts compared to the glide technique. However, there was no significant difference in the actual percentage of foul attempts between the two techniques. The difficulty of the delivery phase in rotational technique was pointed out more than 20 years ago, when rotation was not the mainstream (Lanka, 2000). Furthermore, it has been indicated that the evolution of the rotational technique and its use and perfection from a young age have led to an improvement in the percentage of fouls by the international-level athletes (Salinero & Del Coso, 2021). As the rotational technique has become more commonly used, it can be concluded that there is no superiority between the glide and rotation techniques in terms of the ease of avoiding fouls among the international-level athletes.

The simplicity of the technique has been identified as the reason why even the international-level athletes use the glide technique (Godina & Backes, 2000), which is consistent with the findings of this study on %SB. However, since there was no difference in the rate of foul attempts and the rotational technique has yielded significantly higher records and SBs than the glide technique, it can be assumed that the rotational

technique is becoming the superior technique of the shot put. The recent breaking of the men's world record in 2021, after 31 years drought, is a turning point in the shift towards the rotational technique, as the Fosbury flop become the only technique in the high jump in the world. On the other hand, it has been reported that even the world's elite athletes require more than 10 years to improve their performance using the rotational technique (Babbit & Hoffa, 2016). Since using the rotational technique from a young age has been shown to be the reason for the low rate of foul attempts in male international-level shot putters (Salinero & Del Coso, 2021), it may take a longer period of time for the technical level of the rotational technique to improve. In order to clarify the benefits of using rotational technique, it is necessary to establish a long-term training plan and to gather scientific evidence that can be useful for this purpose.

This study focused on the World Athletics Championships and Summer Olympic Games. However, the participants may have competed in other competitions in the same season, such as national championship, IAAF Golden League, Diamond League, and World Athletics Continental Tour. Based on the periodization and training design, the collected competitions had one of the highest priorities for the participants (Bompa & Buzzichelli, 2018; Gambetta, 2015). However, it is unknown how the difference in records and %SBs between the competitions reflect the actual priority of each competition for each participant. Further examination of results between competitions and the priority of each competition could provide more insight into the characteristics and superiority of the glide and rotational techniques. Additionally, the results of this research are attributed to the inclusion of international level athletes, who may have perfected their rotational technique (Salinero & Del Coso, 2021). The difficulty of the rotational technique may be more apparent in younger generations if the technical perfection is due to its use from a younger age.

Conclusions

The present study compared the rotational and glide techniques based on the performance results obtained from 176 athletes in 16 international-level competitions. The results showed that the glide demonstrated a strength in constantly achieving a higher %SB for each round compared to the rotational technique. However, there was no significant difference in the ratio of foul attempts between the two techniques. Additionally, the frequency of shot putters using the rotational technique increased over time, and the comparison of SB indicated significantly higher results with the rotational technique. Therefore, it can be concluded that the rotational technique has a potential for superior performance, particularly among male shot putters competing at the international level. Longitudinal studies, such as cohort and RCT designs, would provide valuable insights into the potential strengths and weaknesses of both techniques, as well as assist in the selection of appropriate technique during various developmental stages in shot putter development.

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