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Investigation of Freestyle Performance in Swimmers with Different Equipments

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A B S T R A C T

The present study sought to examine the freestyle proficiency of juvenile swimmers deploying various accessories, namely fins, kickboard, and pull-buoy. Twenty-three participants, comprising 14 females and 9 males aged between 10 and 11 years, who reside in Istanbul, pursue activities in exclusive clubs, have held an athlete license for no less than three years, and expressed a keen interest in swimming opted to take part in the study. The research was implemented voluntarily in a private club's indoor swimming pool (25 m short lane). First, the swimmers' body weight, height, and arm length were measured. They then demonstrated their freestyle performance at distances of 25 m, 50 m, 75 m, and 100 m using different equipment: maximal, fins, pull-buoy, and kickboard-only flutter kick. Swimming performances with each piece of equipment were performed two days apart, and all swimmers' performances were recorded with an SJCAM 4k external camera. After conducting the test, the captured images were transferred to the computer and processed using the Kinovea 0.9.5 program in MP4 format. Individual calculations were made for each swimmer's finish time, lap times and velocity for each distance and equipment. The data were evaluated using the IBM SPSS 24.0 analysis program. It was ensured that the data followed a normal distribution ("±1.5"). The comparison of finish times, lap times and velocity of swimmers using different equipment was analyzed using repeated measures variance. There was a statistical difference between the fins, kickboard and pull-buoy in finish time, lap times and velocity ($p<0.05$). While 100 m finish time (108.58±14.99 s) and lap times (21.73±2.71 s - 28.47±3.73 s) performed with fins were found lower than the other equipment, velocity (0.94±0.13 m/s) and lap velocity (1.17±0.14 m/s - 0.89±0.12 m/s) performed with fins were found higher than the other equipment. Therefore, it was concluded that the equipment used in training affected the performance of short-distance freestyle swimming.

Keywords: Swimming equipments, freestyle, performance

INTRODUCTION

Swimming necessitates well-coordinated motions of both upper and lower extremities for propulsion through water. It is widely sought after as a competitive and leisurely sport encompassing every age group as per Peyton and Krabak (2023). Research studies indicate swimming's potential of promoting physical growth in children. Before adolescence, motor control, coordination, and balance are developed by children. Therefore, in addition to swimming training, land-based training can aid in improving the development of a range of motor skills, enhancing coordination between nerves and muscles in swimming techniques, and ultimately increasing efficiency (Burac, 2015; Gelinas and Reid, 2000; Oh et al., 2011; Roj et al., 2016).

Swimming is the proficiency to execute freestyle, backstroke, butterfly, and breaststroke in the shortest possible time in an individual lane, utilizing only body strokes and kicks, in pools that meet international criteria (50 metres (m), 8 lanes) (Gonjo et al., 2022). The freestyle stroke is the swiftest swimming technique based on arm and leg movements, breath control, and head position. In this technique, the body remains balanced parallel to the water while propelling forward by consecutive arm movements and excessive flutter kick in a horizontal direction (Yanai and Wilson, 2008; Hagem et al., 2013). The critical factor for increasing distance covered is achieving the perfect posture. This stance comprises three conditions: 1) Appropriate head position. 2) Straightened back and hip position. 3) Gradual flutter kick. During freestyle swimming, the swimmer's position is not fixed horizontally and may rotate up to 30-40 degrees along the extension axis, depending on the breathing technique used (Bíró et al., 2015). The arms and legs assist the swimmer in making progress and the strokes provide the greatest speed, while the feet contribute only 10% of the speed (Cohen et al., 2015).

Various equipment, such as fins, kickboard, snorkel, and pull-buoy, is used in freestyle swimming training to enhance performance. Swim coaches include fins in training to enhance the ankle flexibility of swimmers. In contrast, the pull-buoy enables swimmers to stabilize their upper body and move through the water by solely using their strokes. The researchers aimed to improve swimming speed by examining its association with the training medium via the pull-buoy. A floating aid frequently employed for training children; the pull-buoy is a type of swimming equipment. The kickboard is designed to facilitate swimmers' concentration on the flutter kick only (Smith et al., 2002; Zamparo et al., 2002; Guzik-Kopyto et al., 2021; Rozi et al., 2020; Mujika & Crowley, 2019).

Swimming performance in juvenile athletes is influenced by efficient movement, motor control, coordination of simultaneous forward movement of body segments and anthropometric characteristics (Fone & van den Tillaar, 2022). Many of these factors are hard to measure, so it is important to study the effect of the equipment used for the development of good performance in juvenile swimmers. Previous studies have investigated the effects of training equipment on swimmers' performance. It is proposed that equipment plays a crucial role in enhancing speed and muscle strength in younger age groups (Zamparo et al., 2002; Matos et al., 2013). Nonetheless, the immediate effects of commonly used equipment such as fins, kickboards, and pull-buoys on freestyle swimming performance, and whether performance differs depending on the equipment used, have yet to be explored. Following a review of the literature, a gap was identified concerning the potential impact of training equipment on freestyle swimming performance among swimmers in different age groups, as well as any performance differences between equipment. To address this gap, the present study aimed to investigate the freestyle performance of young swimmers using different equipment, including fins, kickboards, and pull buoys.

METHOD

The study utilized the descriptive research model, which is one of the quantitative research approaches.

Research Group

The research cohort was made up of male and female swimmers between the ages of 10 and 11 who reside in Istanbul. The sample size of this study was determined to be 23 swimmers using G-Power analysis (G-Power 3.1.9.4) with statistical power set at 90% and the probability of Type I error at 5%. For participant selection, the convenience sampling method was applied (Karagöz, 2021). In total, 23 swimmers who actively engage in swimming at a private club willingly took part in the study, comprising of 14 girls and 9 boys. The study ensured that the swimmers had displayed at least three years of interest in this sport and held a valid licence or athlete card for a minimum of two years. As the subjects were under 18 years of age, they retained the right to withdraw from the study at any time without citing a reason. Table 1 presents the mean and standard deviation of the swimmers' age, height, body weight, body mass index, and arm length.

Tablo 1. Descriptive characteristics of the swimmers

Variables	X̄±S
Age (years)	10.57±0.51
Body Height (m)	1.43±0.09
Body Weight (kg)	35.61±8.87
Body Mass Index (kg/m²)	17.29±2.78
Arm length (m)	1.41±0.12

Data Collection Tools

Height: The subjects' height was measured with a stadiometer with an accuracy of ±1mm with the body in an upright position and barefoot.

Body Weight: The body weight of the subject was measured with an electronic scale with an accuracy of ±0.1kg with the body in an upright position, in a bathing suit, and barefoot.

Body Mass Index (BMI): It was calculated according to the formula body weight/height² (kg/m²) using height and body weight measurements.

Arm Length: The arm length of the subject was measured with a stadiometer with a sensitivity of ±1mm while the subject was barefoot with his/her back against the wall, arms spread to the sides, and parallel to the ground with palms facing forward.

Swimming Performance with Equipment: The study took place in an indoor swimming pool with a short lane measuring 25m, situated within a private club. Participants were instructed to perform freestyle swims at 25m, 50m, 75m, and 100m distances using only fins, a pull-buoy or a kickboard for each swim. The swimmers themselves chose the order in which they used the equipment. The swimmers had trained with the fins, pull-buoys and kickboards for a minimum of one year. Nabaiji's pink or blue fins, Light 500 pull-buoys, and pink or blue kickboards were utilized for measurements. Swimmers conducted swimming performances with each equipment separately on different days. To guarantee a complete rest interval between distances, a minute of passive in-water rest was provided to the swimmers. During the maximal swimming performance, expert coaches used a Casio stopwatch to monitor proximity values of swimmers to 95% of their best race finish time. The objective of this trial is to establish the swimmers' maximum performance levels. Prior to the trial, the swimmers were duly informed of this. All swimmers attained their maximum performance levels during their initial attempt. During the trial, the SJCAM 4k camera was used to record the performances of all swimmers. Following the test, the images were subsequently transferred to a computer and then to the Kinovea 0.9.5 program in MP4 format for video analysis. Images were captured at 1280x720 pixels and 120.01 frames per second (120 fps). The analysis program utilized forward-backward, pause, slow-down, and stopwatch features (Puig-Diví et al., 2017). Finish times, lap times, and velocity values for each distance and equipment were calculated individually for every swimmer. A representation of an image within Kinovea is displayed in Figure 1.

Figure 1. An example of an image in Kinovea 0.9.5

Data Collection

Data was collected from May 2, 2023, to May 23, 2023. To prevent any positive or negative effects on the swimmers' performance, their training was avoided before the measurements were taken throughout the study. Additionally, the swimmers were instructed not to consume any food until two hours before the measurements.

Statistical Analysis

The study employed IBM SPSS 24.0 (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0, Armonk, NY: IBM Corp.) software to determine the normal distribution conformity of the data. Skewness and Kurtosis values were assessed, indicating that they lay between "-1.5" and "+1.5," thus, it was concluded that the data displayed normal distribution (Hair et al., 2014). The swimmers' finishing times, lap times and velocities were compared using different types of equipment. The analysis was carried out with repeated measures of variance. The p-value from the Mauchly's Test of Sphericity was used to determine whether to use the p-value from the Sphericity Assumed test (if $p > 0.05$) or Wilks' Lambda test from Multivariate tests (if $p < 0.05$). Using the partial eta squared coefficient (η2p) produced by the analysis, effect sizes were categorized as small (~0.01), medium (~0.06), and large (~0.14) following Cohen's (1988) guidelines. Statistical significance was determined at $p<0.05$.

Limitations of the study

One of the limitations of the study is that the swimmers in the study were only 10-11 age group. In addition, the maximum distance swum was determined as 100 meters. In addition, the use of three equipment in the study can be considered as one of the limitations of the study.

RESULTS

Table 2. Comparison of mean and standard deviation values of swimmers' finish time and velocity according to different equipment

Variables		Maximal	Fins	Pull-buoy	Kick	p	η^2p
Finish Time (s)	25 m	24.17±3.46	20.85±2.37	28.43±3.65	29.96±3.32	0.001*[abcde]	0.961
	50 m	56.66±10.94	48.33±5.94	63.22±9.95	69.54±6.67	0.001*[abcdef]	0.967
	75 m	89.52±13.62	78.52±10.23	102.92±22.73	112.44±13.31	0.001*[abcde]	0.953
	100 m	125.13±18.44	108.58±14.99	140.53±23.61	154.12±16.10	0.001*[abcde]	0.970
Velocity (m/s)	25 m	1.05±0.15	1.22±0.14	0.89±0.11	0.84±0.10	0.001*[abcde]	0.816
	50 m	0.91±0.16	1.05±0.13	0.81±0.12	0.73±0.07	0.001*[abcdef]	0.965
	75 m	0.86±0.13	0.97±0.13	0.76±0.15	0.67±0.07	0.001*[abcde]	0.948
	100 m	0.82±0.12	0.94±0.13	0.73±0.12	0.66±0.07	0.001*[abcdef]	0.945

*$p<0.05$; a: Maximal vs Fins; b: Maximal vs Pull-buoy; c: Maximal vs Kick; d: Fins vs Pull-buoy; e: Fins vs Kick; f: Pull-buoy vs Kick

Table 2 presents the mean and standard deviation of finish time and velocity parameters of swimmers, as well as comparisons between different equipment. Significant statistical differences were observed in the 25 m, 50 m, 75 m, and 100 m distances between swimming with equipment and maximal swimming. Significant differences were found between fins and pull-buoy in finish time in 25 m, 50 m, 75 m, and 100 m, respectively 20.85±2.37 s - 28.43±3.65 s; 48.33±5.94 s - 63.22±9.95 s; 78.52±10.23 s - 102.92±22.73 s; 108.58±14.99 s - 140.53±23.61 s. Significant differences were found between fins and pull-buoy in velocity in 25 m, 50 m, 75 m, and 100 m, respectively 1.22±0.14 m/s - 0.89±0.11 m/s; 1.05±0.13 m/s - 0.81±0.12 m/s; 0.97±0.13 m/s - 0.76±0.15 m/s; 0.94±0.13 m/s - 0.73±0.12 m/s. There were significant differences in finish time between using fins and a kickboard for distances of 25m, 50m, 75m, and 100m, respectively 29.96±3.32 s, 69.54±6.67 s, 112.44±13.31 s, and 154.12±16.10 s with kickboard. There were significant differences in velocity between using fins and a kickboard for distances of 25m, 50m, 75m, and 100m, respectively 0.84±0.10 m/s, 0.73±0.07 m/s, 0.67±0.07 m/s, and 0.66±0.07 m/s with kickboard. These differences were highly significant ($p<0.05$).

Table 3. Comparison of mean and standard deviation values of swimmers' lap time and velocity according to different equipment

Variables		**Maximal**	**Fins**	**Pull-buoy**	**Kick**	**p**	**η^2p**
	LP1_50 m	26.01±4.19	21.73±2.71	29.86±4.67	31.69±3.82	0.001*abcde	0.944
	LP2_50 m	30.46±6.51	26.60±3.67	33.84±6.60	38.02±3.45	0.001*abcde	0.955
	LP1_75 m	26.41±4.09	23.23±3.83	30.33±4.93	32.56±4.09	0.001*abcde	0.965
	LP2_75 m	31.84±4.74	27.39±3.42	34.85±6.67	40.73±4.90	0.001*abcdef	0.935
Lap Time (s)	LP3_75 m	31.43±5.70	27.94±3.99	35.31±6.92	39.32±4.83	0.001*abcde	0.893
	LP1_100 m	28.91±4.82	23.98±3.13	32.23±4.76	35.58±4.96	0.001*abcde	0.954
	LP2_100 m	31.63±5.30	28.43±4.02	35.70±6.50	39.40±3.52	0.001*abcde	0.944
	LP3_100 m	33.64±4.54	28.47±3.73	35.91±6.19	40.70±3.87	0.001*abcdef	0.940
	LP4_100 m	31.29±5.80	27.78±5.43	36.71±7.41	38.73±6.25	0.001*abcde	0.846
	V1_50 m	0.98±0.14	1.17±0.14	0.86±0.13	0.80±0.09	0.001*abcde	0.822
	V2_50 m	0.86±0.18	0.96±0.13	0.76±0.14	0.66±0.06	0.001*abcdef	0.933
	V1_75 m	0.97±0.14	1.10±0.17	0.84±0.13	0.78±0.09	0.001*abcde	0.930
	V2_75 m	0.80±0.12	0.93±0.12	0.74±0.14	0.62±0.07	0.001*abcdef	0.921
Lap Velocity (m/s)	V3_75 m	0.82±0.15	0.91±0.14	0.73±0.14	0.64±0.07	0.001*abcdef	0.686
	V1_100 m	0.89±0.14	1.06±0.14	0.79±0.11	0.72±0.10	0.001*abcde	0.941
	V2_100 m	0.81±0.14	0.90±0.13	0.72±0.13	0.64±0.06	0.001*abcdef	0.895
	V3_100 m	0.76±0.10	0.89±0.12	0.72±0.12	0.62±0.06	0.001*abcdef	0.893
	V4_100 m	0.83±0.15	0.93±0.18	0.71±0.13	0.66±0.12	0.001*abcde	0.829

*$p<0.05$; a: Maximal vs Fins; b: Maximal vs Pull-buoy; c: Maximal vs Kick; d: Fins vs Pull-buoy; e: Fins vs Kick; f: Pull-buoy vs Kick; LP1: First Lap Time (25 m); LP2: Second Lap Time (25 m); LP3: Third Lap Time (25 m); LP4: Fourth Lap Time (25 m); V1: First Velocity (25 m); V2: Second Velocity (25 m); V3: Third Velocity (25 m); V4: Fourth Velocity (25 m)

The mean and standard deviation values for finish time and velocity parameters for swimmers, as well as their comparison based on varying equipment, are presented in Table 3. The table indicates a statistically significant difference ($p<0.05$) in lap time and velocity values at lap distances between swimming with equipment and swimming at maximal capacity at 25 m, 50 m, 75 m, and 100 m distances. Significant differences were found between fins, pull-buoy and kick-board in lap time (minimum values respectively 21.73±2.71 s, 29.86±4.67 s, and 31.69±3.82 s) and lap velocity (minimum values respectively 0.89±0.12 m/s, 0.71±0.13 m/s, and 0.62±0.06 m/s) values in 25 m, 50 m, 75 m, and 100 m. These differences exhibited a high effect size ($p<0.05$).

DISCUSSION AND CONCLUSION

The study concluded that the equipment employed in swimming training has an impact on short-distance freestyle swimming performance. The findings indicate differences in short-distance freestyle swimming finish time, lap times and velocity depending on the equipment used.

In order for swimmers to achieve optimal race performance, certain equipment is used for training. Hand fins, kickboards, pull-buoys, snorkels, and fins are all examples of equipment used in swimming (Matos et al., 2013; Jagomägi and Jürimäe, 2005; Agopyan et al., 2012). Studies have indicated that flutter kicks contribute to around 10% of the overall stroke rate (Hollander et al., 1988). Fins are utilised during training to enhance the flutter kick and improve ankle flexibility. This apparatus enables swimmers to utilize their hips and conduct the whole leg movement (Smith et al., 2002). In seven male swimmers, Zamparo et al. (2002) observed a 40% decline in energy usage and an increase in speed of 0.2 m/sec when comparing swimming with fins to traditional swimming. Zamparo et al. (2005) found identical results in another study, indicating that the use of fins decreases energy expenditure during swimming. Matos et al. suggest that coaches should consider alterations in swimming biomechanics due to the use of hand and kick fins when determining distances and intensities. A meta-analysis of thirty studies reveals that fins have a link with the average stroke frequency, average swimming velocity, kick frequency, kick depth, and energy expenditure, although hand fins showcase an association with stroke length, stroke frequency, average swimming velocity, coordination index, and absolute duration of stroke phases (Matos et al., 2013). To enhance performance of the flutter kick and increase ankle flexibility, it is advised to use a kickboard during practice (McCullough et al., 2009; Maglischo, 2003). Montgomery & Chambers, 2008; The implementation of flutter kicks while using kickboards enables swimmer to exclusively concentrate on the movements of their lower limbs (Montgomery & Chambers, 2008). McCullough et al. (2009) found a correlation between ankle plantar flexibility and kick velocity. Their biomechanical analysis suggests that swimmers with flexible ankles have better swimming performance. In order to improve upper body balance, a pull-buoy is typically utilised in swimming, which restricts the use of the legs and enhances arm strength. Furthermore, the pull buoy also serves to restrict and correct the flutter kick of athletes who spread their feet too far apart (Smith et al., 2002). Ramón and Valero (2018) highlighted the importance of incorporating both equipment-based and non-equipment-based training in swimming lessons for middle school students. The study explored the impact of kickboard and pull-buoy use in physical education classes. The authors suggested that a balance of both methods is essential for an effective swimming curriculum.

Our research has revealed variations in the equipment used to train child swimmers in terms of speed and duration. The experimentation demonstrated that fins enabled swimmers to attain higher speeds. Additionally, utilizing flutter kick with kickboards resulted in the slowest speeds. Young coaches for age group swimming are advised to tailor their training programs according to the equipment used, with consideration given to factors such as the number of repetitions, distance, and rest periods. It should be noted that the use of kickboards and fins can affect the flutter kick (lower extremity), while the pull-buoy can impact stroke technique (upper extremity). During dedicated training periods, swimming equipment is utilised to enhance the strength of swimmers in resistance and sprint training, ultimately increasing speed and muscle strength. This equipment requires swimmers to contend with heightened water resistance. Therefore, it is recommended that swimmers use this equipment to cultivate both technique and speed.

Future studies on this subject should investigate older swimmers with a larger sample size. Additionally, it would be worthwhile to explore whether there is a performance difference between equipment used in different styles. The performance in distances over 100 metres can also be compared with the equipment. Another suggestion is to include the hand pallet alongside the fins, kick-board, and pull-buoy in elderly athletes. It is recommended to compare these pieces of equipment with each other for optimal results

Conflict of Interest

No potential conflict of interest was reported by the authors.

Ethical Approval

Ethical clearance was granted by the Haliç University Non-Interventional Clinical Research Ethics Committee on 25.04.2023 (No: 117) prior to initiating the data collection phase of the study. The scope of the research was presented to the swimmers and their families in written and verbal format. Written informed consent was obtained from the participants and their families after the explanation. The scope of the research was presented to the swimmers and their families in written and verbal format.

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