



A comparative study on strength differences among swimmers of different strokes

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Abstract

Swimming is a popular and effective form of exercise that engages the whole body, enhancing strength, endurance, and flexibility. It involves moving through water using various techniques, known as strokes. The four primary swimming strokes are: the freestyle (front crawl), the backstroke, the breaststroke, and the butterfly. All four strokes require specific motor fitness component to achieve the peak performance in the stroke. The aim of the study was to compare the maximum leg strength and leg explosive strength of swimmers of all four strokes. Total 80 subjects were purposively selected for the study (20 from each stroke) from Maharashtra state. The subjects performing IM as event were excluded from the study. The age of the subjects was ranged between 18 to 25 years. The independent variables selected for the study were Maximum leg strength measured by using dynamometer and leg explosive strength by using vertical jump test. The data were collected as per the ethical procedure. The result of the study showed the maximum leg strength as (Breast stroke (145.40±23.57) > Butterfly (139.35±19.51) > Back stroke (129.47±14.82) > Free style (128.85±18.565)). The breast stroke demonstrates significant higher maximum leg strength compared to the backstroke and freestyle due to the nature of its kick, which is more explosive and requires a greater degree of power to achieve the necessary propulsion and body position. This explosive movement demands significant activation of fast-twitch muscle fibers and high force output from the legs. Also results showed that the leg explosive strength as (Breast stroke (55.65 ± 9.033) > Butterfly (43.40 ± 4.772) > Back stroke (42.75 ± 6.679) > Free style (40.200 ± 4.708)). The sequence of leg explosive strength of various strokes shoes the biomechanics and muscle activation patterns of each stroke, where strokes requiring more powerful, burst-like movements (breaststroke and butterfly) demand greater leg strength than those with continuous, rhythmic movements (backstroke and freestyle).

Keywords: Maximum leg strength, leg explosive strength, dynamometer

Introduction

Swimming is a popular and effective form of exercise that engages the whole body, enhancing strength, endurance, and flexibility. It involves moving through water using various techniques, known as strokes. The four primary swimming strokes are: the freestyle (front crawl), which is the fastest stroke and typically used in competitions; the backstroke, performed on the back with alternating arm movements; the breaststroke, a slower, more methodical stroke with a frog-like kick; and the butterfly, a challenging stroke requiring synchronized arm movements and a powerful dolphin kick. Each stroke emphasizes different skills and techniques in the water. In swimming, each stroke requires different amounts of strength and utilizes various muscle groups. The book (Science and Practice of Strength Training, 2006) defines maximum strength as the highest force a muscle or muscle group can produce, which is often tested in strength training exercises and is a key factor for improving athletic performance. The authors (Zatsiorsky, 2006) [6] define explosive strength as the ability to produce maximum force in the shortest period of time, emphasizing its importance in sports that demand fast and powerful movements.

Freestyle or Front Crawl stroke demands high upper body strength for continuous arm movements, along with strong leg propulsion for efficient movement. The kick provides speed, but the arms drive most of the power. key muscle groups used for propulsion in stroke are Core, shoulders, triceps, and legs (McLeod, 2009) [1]. The author (Maglischo, 2003) [3] emphasizes the importance of maximum strength in the arm pull and leg kick to achieve the fastest performance in freestyle. In backstroke, swimmers use shoulder and core

strength to maintain consistent strokes while kicking with the legs for speed and stability. The key muscles used by swimmer while performing back stroke are Shoulders, back, core, and legs (Counsilman, 1968) [2]. The breaststroke relies heavily on the strength of the legs for the frog-like kick and the arms for the pulling motion. The kick is the most power-intensive part of this stroke. The muscles of Chest, triceps, core, and legs works as the key muscles for performing the breast stroke (Maglischo, 2003) [3]. Butterfly is the most demanding stroke, requiring maximum upper body strength for the simultaneous arm movement and significant core and leg strength for the undulating motion of the body. Muscles of Shoulders, chest, back, core, and legs plays major role while performing butterfly (Thomas, 2005) [4]. Each stroke emphasizes different aspects of strength, with the butterfly generally requiring the greatest overall muscular exertion due to the need for coordination and explosive power.

After going through the research work and experts' opinion it was hypothesized that there will be significant difference between the maximum leg strength of swimmers of different strokes and also it was hypothesized that leg explosive strength will significantly vary between all the four strokes.

Selection of subjects

Total 80 subjects were selected for the study (20 from each stroke) from Maharashtra state. The criteria for selection of the subject were that the subject must have participated 3 times in state level in their event. The subjects performing IM as event were excluded from the study. The age of the subjects was ranged between 18 to 25 years.

Sampling procedure

For selection of the subject purposively sampling procedure will be employed.

Selection of variables

The independent variables selected for the study are

- Leg explosive strength
- Maximum leg strength

The dependent variables selected for the study are

- Front crawl
- Breast stroke
- Back stroke
- Butterfly

Methodology

To measure the leg explosive strength of swimmers across all four strokes (freestyle, backstroke, breaststroke, and butterfly) using the vertical jump test method. The researcher gave a brief on the test and provide consent to all participants. First of all, Swimmers perform a 10-minute dynamic warm-up, focusing on lower body muscles (legs, hips, calves, and core). Each swimmer was instructed to perform the vertical jump technique, ensuring they know how to jump from a standing position without any initial movement or steps. Swimmer will stand erect near the wall. Swimmers are instructed to crouch slightly and then perform an explosive jump to reach as high as possible. Their arms should be used for added propulsion but should not interfere with the measurement device. Record the height of the jump from the base of the device or the highest point they can reach on the Vertex. After each jump, allow a 30-60 second rest period to ensure proper recovery. Each swimmer performs 3 jumps, with the highest of the three measurements taken as the final score. Record the maximum vertical jump height for each swimmer in centimeters or inches (Zatsiorsky, 2006) [5].

To assess the maximum leg strength of swimmers from all four strokes dynamometer was used, which measures the maximum force exerted by the legs during a leg strength

test. Obtain written consent from all participants, explaining the purpose, procedure, and any potential risks involved. Participants should perform a 10-minute dynamic warm-up (e.g., light jogging, leg swings, lunges) to activate the muscles and prevent injury. Brief each swimmer on the procedure, emphasizing the importance of exerting maximum force during the test. The swimmer will sit in a chair or on a bench with their knee bent at approximately 90 degrees, ensuring the thigh is parallel to the floor. The dynamometer is placed against the leg, typically around the ankle or lower leg, to assess the force generated by the quadriceps, hamstrings, and calf muscles. If using a handheld dynamometer, the tester should apply pressure against the participant’s leg while they push against it. If using a machine-based dynamometer, the participant will apply force to a fixed pad or lever. Swimmers should be seated comfortably and instructed to apply maximal force using their leg. The tester will secure the dynamometer against the swimmer’s leg to ensure proper contact and accurate measurement. The swimmer will be instructed to push against the dynamometer with maximum strength for approximately 5-10 seconds, generating as much force as possible. After each trial, swimmers should rest for 30-60 seconds to avoid fatigue impacting the next measurement. Each swimmer will perform three trials with the dynamometer, and the highest force measurement from the three trials will be recorded as the maximum leg strength. Record the peak force generated during each trial in kilograms (kg) or pounds (lbs), depending on the dynamometer’s unit of measurement. Note the highest recorded force across all trials as the swimmer’s maximum leg strength. Participation is voluntary, and participants may withdraw at any time without penalty. Data will be kept confidential and used solely for the purpose of the study. By using a dynamometer, this methodology provides a reliable and objective method for assessing the maximum leg strength of swimmers across different strokes.

Result and discussion

Table 1: Descriptive statistics of maximum leg strength of different strokes of swimming

Swim strokes/Descriptive stats	N	Mean	Std. Deviation	Std. Error
Freestyle	20	128.8500	18.56504	4.15127
Breast stroke	20	145.4000	23.57050	5.27052
Back stroke	20	129.4750	14.82483	3.31493
Butterfly	20	139.3500	19.51052	4.36269
Total	80	135.7688	20.24345	2.26329

Table 2: One-way analysis of variance of maximum leg strength

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3861.334	3	1287.111	3.431	.021
Within Groups	28512.638	76	375.166		
Total	32373.972	79			

The table 2 shows that significant value is (0.021<0.05) lesser than the significant value. Hence the table shows that there is significant difference between the maximum leg

strength of all the four groups. To see the accurate difference between the groups further the Post Hoc test was applied.

Table 3: Post Hoc test (LSD) applied on maximum leg strength values of different strokes of swimming

(I) Maximum leg strength	(J) Maximum leg strength	Mean Difference (I-J)	Std. Error	Sig.
Freestyle	Breast stroke	-16.55000*	6.12508	.008
	Back stroke	-.62500	6.12508	.919
	Butterfly	-10.50000	6.12508	.091

Breast stroke	Freestyle	16.55000*	6.12508	.008
	Back stroke	15.92500*	6.12508	.011
	Butterfly	6.05000	6.12508	.326
Back stroke	Freestyle	.62500	6.12508	.919
	Breast stroke	-15.92500*	6.12508	.011
	Butterfly	-9.87500	6.12508	.111
Butterfly	Freestyle	10.50000	6.12508	.091
	Breast stroke	-6.05000	6.12508	.326
	Back stroke	9.87500	6.12508	.111

*. The mean difference is significant at the 0.05 level.

Table 3 shows the significant values and it is found that the significant difference is found between freestyle and breast stroke (0.008<), breast stroke and back stroke (0.011<).

Table 4: Descriptive statistics of leg explosive strength of different strokes of swimming

Swim strokes/Descriptive stats	N	Mean	Std. Deviation	Std. Error
Freestyle	20	40.2000	4.70834	1.05282
Breast stroke	20	55.6500	9.03371	2.02000
Back stroke	20	42.7500	6.67970	1.49363
Butterfly	20	43.4000	4.77273	1.06721
Total	80	45.5000	8.79730	.98357

Table 5: One-way analysis of variance of leg explosive strength

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2861.700	3	953.900	22.291	.000
Within Groups	3252.300	76	42.793		
Total	6114.000	79			

The table 5 shows that significant value is (0.000<0.05) lesser than the significant value. Hence the table shows that there is significant difference between the leg explosive

strength of all the four groups. To see the accurate difference between the groups further the Post Hoc test was applied.

Table 6: Post Hoc test (LSD) applied on leg explosive strength values of different strokes of swimming

(I) Maximum leg strength	(J) Maximum leg strength	Mean Difference (I-J)	Std. Error	Sig.
freestyle	Breast stroke	-15.45000*	2.06866	.000
	Back stroke	-2.55000	2.06866	.221
	Butterfly	-3.20000	2.06866	.126
breast stroke	Freestyle	15.45000*	2.06866	.000
	Back stroke	12.90000*	2.06866	.000
	Butterfly	12.25000*	2.06866	.000
back stroke	Freestyle	2.55000	2.06866	.221
	Breast stroke	-12.90000*	2.06866	.000
	Butterfly	-.65000	2.06866	.754
Butterfly	Freestyle	3.20000	2.06866	.126
	Breast stroke	-12.25000*	2.06866	.000
	Back stroke	.65000	2.06866	.754

*. The mean difference is significant at the 0.05 level.

Discussion

Maximum leg strength

After analyzing the descriptive value (Table 1) the researcher found that maximum leg strength is seen maximum in following sequence: -

Breast stroke > Butterfly > Back stroke > Free style

Also, the post hoc test shows the significant difference between the freestyle and breast stroke. In breaststroke, the leg movement is characterized by a frog-like kick, where the swimmer draws the legs in towards the body before forcefully extending and pushing the water backward to propel the body forward. This movement requires significant muscular power, particularly from the quadriceps, hamstrings, glutes, and calves, as these muscles are involved in both the initial draw and the final push. Studies have shown that the peak leg force generated in breaststroke is significantly higher than in freestyle due to the nature of the leg movements. For example, a study by

Mendiguchía *et al.* (2015) [7, 15] and Marelic *et al.* (2019) [8] found that the peak propulsive forces from the legs in breaststroke are greater than those in freestyle due to the more powerful push-off required during the stroke cycle. Research published in the Journal of Sports Sciences (2011) also supports the idea that the breaststroke kick, due to its mechanics, demands more from the lower limbs, particularly the quadriceps and glute muscles, compared to the freestyle flutter kick. The butterfly's kick is often referred to as a "dolphin kick," which is executed with both legs moving together in a fluid motion. The downward phase of the dolphin kick is where the maximum leg force is generated to push the swimmer forward. The kick demands quick, forceful movements and is energetically costly, requiring high levels of power to overcome the water's resistance. The backstroke and freestyle, while also involving leg kicks, are more focused on continuous, repetitive, and less intense efforts. In freestyle, the flutter kick involves less explosive power as it is more focused on

maintaining balance and speed rather than generating maximal propulsion. Similarly, the backstroke kick is steadier, and while it still involves propulsion, it is not as forceful as the butterfly kick. Studies have shown that the butterfly stroke requires a significant amount of leg strength for the downward kick to generate thrust and lift the body, especially in swimmers with high performance. According to research by Chollet *et al.* (2000)^[10, 14], the butterfly kick generates higher peak forces compared to the freestyle and backstroke kicks due to the explosive nature of the movement and the larger muscle groups involved. Girolid *et al.* (2007)^[11, 13] also found that the butterfly stroke requires more muscular force in the lower limbs than the backstroke, primarily due to the increased intensity of the kick and the need for greater propulsion and body positioning to maintain the stroke's rhythm and speed.

Leg explosive strength

After analyzing the descriptive value (Table 4) the researcher found that leg explosive strength is seen maximum in following sequence: -

Breast stroke > Butterfly > Back stroke > Free style

The breaststroke kick primarily activates large muscle groups in the lower body, such as the quadriceps, hamstrings, glutes, and calves. This kick requires high force production because it needs to overcome water resistance efficiently and propel the swimmer forward with each stroke. The explosive nature of the kick and the large muscle groups involved in generating force make the breaststroke the stroke that demands the highest leg explosive strength. B. Lohman *et al.* (2012)^[12] found that the breaststroke leg action involves both large muscle groups and explosive force, requiring high peak forces and thus high leg strength. The butterfly's explosive leg movement requires recruitment of fast-twitch muscle fibers, particularly in the glutes, hamstrings, and calves, during the push-off phase. However, the amplitude and intensity of the butterfly kick are not as high as the breaststroke kick because the butterfly is more coordinated with the body undulation. Girolid *et al.* (2007)^[11, 13] highlight that the butterfly kick requires significant leg strength, though it's not as forceful as the breaststroke kick. The backstroke kick primarily involves the activation of the hip flexors, quadriceps, and hamstrings, but it does not require the same explosive strength as the butterfly or breaststroke. The push-off during the backstroke is less forceful because the leg movements are more rhythmic and aimed at maintaining consistent speed rather than producing bursts of power. Chollet *et al.* (2000)^[10, 14] found that the backstroke kick produces less peak propulsion than both the breaststroke and butterfly kicks due to its steady and rhythmic nature. While the flutter kick in freestyle still plays an important role in maintaining body position and momentum, it does not require the same peak force as the explosive pushes in breaststroke and butterfly, which focus on large bursts of power. A study by Mendiguchía *et al.* (2015)^[7, 15] emphasized that the freestyle kick relies on endurance, with less emphasis on maximal explosive strength in the legs compared to other strokes.

Conclusion

The breast stroke demonstrates higher maximum leg strength compared to the backstroke and freestyle due to the nature of its kick, which is more explosive and requires a

greater degree of power to achieve the necessary propulsion and body position. This explosive movement demands significant activation of fast-twitch muscle fibers and high force output from the legs. The sequence of leg explosive strength of various strokes shows the biomechanics and muscle activation patterns of each stroke, where strokes requiring more powerful, burst-like movements (breaststroke and butterfly) demand greater leg strength than those with continuous, rhythmic movements (backstroke and freestyle).

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