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CONFERENCE PAPER

Active Drag Device for Resistance Training in the Pool

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ABSTRACT

Swimming resistance gearis aimed at conditioning competitive swimmers. As part of a training program,competitive swimmers are typically cycled through training strokes withelements of additional resistance to build strength, resilience and simulate fatigue.The challenge is provide variable resistance levels within a single session,dependent on specific needs and training objectives. In this paper variedconcepts were created that make use of remote wireless control systems and werecompared in a criteria weighted Pugh Matrix. The winning concept, a tetheredcone device, scored highly for its simplicity and cost. Although the product isinitially aimed at elite athletes, it is likely that the design will have utilityin recreational swimming and rehabilitation.

Keywords: drag, swimming, resistance training

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INTRODUCTION

Swimming resistance gear is aimed at conditioning competitive swimmers. As part of a training programme, competitive swimmers are typically cycled through training strokes with elements of additional resistance to build strength, resilience and simulate fatigue. In general the resistance gear can be broken into 3 categories:

1. Devices that connect the swimmer to the pool side; for example an elastic band.
2. Devices that attach to the swimmer and trail behind; for example a parachute or cone.
3. Devices that are worn to simply increase the swimmers overall drag; for example a drag suit, or hand paddles.

Studies have demonstrated that swimmers who receive high resistance training in the water have improved force, velocity and power outputs culminating in significant improvements in race times, especially in 50 – 200m sprints.[1, 2, 3] However, despite some drag devices having resistances that can be adjusted before a training session, controlling the intensity of the exercise in the aquatic environment continues to be challenging. This has limited the application of drag devices for all users.[4, 5] The challenge is to not only maintain, but also reduce or increase resistance levels within a single session, dependent on specific needs and training objectives. This is important because fatigue often results in a loss of technique.[5] If an athlete trains poorly, this may instil poor habits i.e. a situation to avoid. Therefore an 'active' drag device that can be controlled by the trainer at the pool side where resistance can be varied to reduce risk of bad habit formation.

Griffith University are undertaking a research and

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development project to design, analyse, build and test a wireless operated active drag device. The project has several stages beginning with a conceptual design study to propose a viable design. The viable design will firstly be analysed using Computational Fluid Dynamics (CFD) to determine the drag characteristics followed by flume tank calibration. The final stage will be to test the device for swimmer comfort and performance.

ACTIVE DRAG CONCEPTS

Five varied concepts were developed by a team that included professional engineers, industrial designers, sports technologists and a swimming coach. The five concepts were:

1. Inflatable cap – a device worn on the head that can be inflated with water through a vascular system.
2. Tethered propeller device – a caged propeller concept that creates a thrust in the opposite direction to the swimmer. The level of drag can either be increased by increasing the speed of the propeller or by simply rotating the blades to change the angle of the oncoming flow. Reversing the thrust would turn it into an assist device.
3. Overhead cable – In this concept the swimmer is simply tethered to an overhead cable. The drag on the swimmer can be adjusted by clamping brushes on to the cable thus increasing the friction.
4. Torpedo drone – drone technology has matured in the past five years. In this concept an underwater drone is tethered to the swimmer and provides an opposing thrust. Similar to the Tethered propeller concept, the device could also be used as an assist device simply by having the drone moving in the same direction as the swimmer.
5. Tethered cone – this concept borrows from tethered passive devices that currently exist in the market. The significant difference is the ability of the drag device to change the level of drag on the swimmer without the swimmer having to stop.

All these concepts can make use of remote wireless control systems. This will enable a coach to adjust the drag on the swimmer actively from the side of the pool or have autonomous control based on sensory feedback from the swimmer.

To compare the concepts a Pugh Matrix was developed by the team. This common decision making technique compares candidates against agreed weighted criteria. [6] In order to decide which design concept to develop the candidate designs were scored out of 10 on their ability to meet the following criteria:

- *Price:* The lower the unit selling price, the greater the opportunities will be for penetration into the sports equipment market. Analysis shows that squad swimmers are prepared to spend up to $1000 for a swimsuit for performance improvement.
- *Unit cost:* The cost of manufacturing will depend on the ease of manufacturing, material costs and the component costs.
- *Transportability:* One person should be able to carry and install the device. No special fixtures should be needed at the pool for installation.
- *Stroke Mechanics*: The device should not interfere with the swimmer's stroke action.
- *User comfort:* The device must be comfortable for the swimmer throughout a swimming set.
- *Turning:* The device must not impede the swimmer during tumble turns.
- *Controllability:* The level of resistance needs to be controlled from the pool side. Controllability is assessed by the range of imposed resistance, the number of resistance intervals and the reaction time.
- *Reliability:* The device must not break, tangle or be caught whilst in use and have a usage time of 20 minutes. The device must also be fully waterproof.
- *Aesthetics:* It is assumed that the more aesthetically pleasing the device is the more popular it will become in the market.
- *Safety:* The safety is concerned with the users and the environment around them. The device must not harm the user or the surrounding swimmers. Furthermore, safety precautions must be in place for devices involving electronic components.

Table 1: Pugh decision matrix

	Criteria Weighting	#1 Inflatable cap	#2 Tethered propeller	#3 Over head cable	#4 Torpedo drone	#5 Tethered Cone
Price	1.0	9.00	6.00	3.00	5.00	8.00
Unit Cost	1.0	6.00	6.00	2.00	5.00	8.50
Transportability	1.0	9.00	7.50	2.00	7.50	8.00
Stroke Mechanics	1.5	11.25	12.75	12.00	12.00	12.75
User comfort	1.5	6.00	11.25	10.50	11.25	11.25
Turning	1.0	8.00	6.00	4.50	6.00	6.00
Controllability	1.5	6.00	12.00	12.75	10.50	12.75
Reliability	1.0	6.00	6.00	6.50	5.00	7.50
Aesthetics	1.0	4.00	6.00	3.00	8.00	6.50
Safety	1.0	9.00	5.00	4.00	5.50	8.00
WEIGHTED TOTAL (scored out of 115)		74.25	78.50	60.25	75.75	89.25

Three criteria, nominated as critical to achieving the specified outcomes, were consequently awarded a weighting of 1.5x by the team.

PRACTICAL APPLICATIONS

Although the product is initially aimed at elite athletes, it is likely that a design with the intended features and price estimation of AU$250 will have commercial value as a training device in the wider recreational swimming market. In the USA alone there are an estimated 4,500,000 amateur swimmers.

Aquatic rehabilitation has also been demonstrated to significantly improve muscle performance and endurance in people with low fitness, for early rehabilitation of injured athletes, for the elderly and suffers of arthritis and knee disorders.[4] Active drag devices could play an important role in progressive hydrotherapy programs to apply controlled resistances safely for rehabilitation purposes.

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