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An Intelligent Identification Model for the Selection of Elite Rowers by Incorporating Internet-of-Things Technology

JING-WEI LIU[1], SHENG-HSIANG CHEN[1], YEN-CHEN HUANG[2,3], AND CHING-TANG WANG[1]
[1]Department of Sport Information and Communication, National Taiwan University of Sport, Taichung 404, Taiwan
[2]Department of Recreational Sport, National Taiwan University of Sport, Taichung 404, Taiwan
[3]Graduate Institute of Recreational Sport Management, National Taiwan University of Sport, Taichung 404, Taiwan
Corresponding author: Sheng-Hsiang Chen (harvestpaleale@gmail.com)

ABSTRACT Over the last few decades, the training methods for rowers have been converging toward similar models owing to the progress in science and technology, in particular, the increased flow of information. As a result, rowing performance in competitions at the international level is the best it has ever been. However, it is possible to further enhance rowers' performance. An important first step to obtain an advantage on the race course is the selection of rowing athletes. The selection method presented here began by inviting experts and scholars in the field to complete a questionnaire, which was established through the analysis and compilation of relevant literature on rowing and athlete selection. Subsequently, the modified Delphi method is applied to achieve an expert consensus on the selection criteria to be evaluated. Five primary criteria, including athlete monitoring via internet-of-things (IoT) technology, and twenty sub-criteria were identified for the selection of elite rowers. An evaluation model for the athletes was constructed from the data using the analytic hierarchy process. The results showed that when selecting rowers the primary criterion of body factor has the highest priority, followed by IoT measurement factor, professional factor, reaction factor, and psychological factor. Furthermore, it reveals that the important sub-criteria affecting athlete selection are body composition, muscle composition, and competition scores. The framework provided by this study for the selection of elite rowers can be refined and adapted for the selection of elite athletes in related sports.

INDEX TERMS Analytic hierarchy process, Internet-of-Things (IoT), modified Delphi method, rowing, selection model.

I. INTRODUCTION

In the Olympic Games, there are eight men's and six women's rowing events. Moreover, every year the International Rowing Federation (FISA) holds the World Rowing Championships, the World Rowing Cup, the World Rowing U23 Championships, and the World Rowing Junior Championships. In addition to these international competitions, rowing events in the Asian Games, Asian Rowing Championships, Asian Rowing Junior Championships, National Games, and National Rowing Championships of Taiwan are major competitions for Taiwanese and international rowers [1]. Taiwan (Chinese Taipei) won its first rowing medal at an international level at the 1994 Hiroshima Asian Games (in the women's coxless fours event). Since then, Taiwanese rowers have obtained a bronze medal at the 1998 Bangkok Asian Games (women's coxless fours), a silver medal at the 2002 Busan Asian Games (women's coxless fours), a silver medal at the 2010 Guangzhou Asian Games (men's single sculls), a silver medal at the 2014 Incheon Asian Games (men's double sculls), and a silver medal at the 2018 Jakarta Asian Games (women's single sculls). In total, Taiwan has won four silver medals and two bronze medals for rowing in the Asian Games. Moreover, Taiwan has achieved Olympic qualification several times. The achievements of Taiwanese rowers demonstrate the medal winning potential of the sport for Taiwan. Therefore, the development of rowing in Taiwan deserves scientific attention.

Reference [2] noted that effective training in rowing requires long-term mental, strength, and endurance

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components. However, the physical characteristics of the athletes are also important. Reference [3] believed that successful sporting talent selection had a major impact on the success of the training in producing elite rowers. Reference [4] further noted that the athletes with excellent congenital physical characteristics, coupled with the scientifically developed training and daily efforts, are able to achieve outstanding performance. Aided by the advancement of science and technology, the level of sporting competition is rapidly increasing and the flow of information in all aspects of sport has become fast and convenient. The different methods, means and equipment used for training around the world are converging toward a similar model. In this highly competitive environment, there remains the potential to gain an advantage by examining the selection of athletes. Reference [5] reviewed the literature on basketball player selection nationally and internationally, as well as suggestions from basketball experts and scholars to establish an evaluation model for the abilities of professional basketball players, providing basketball coaches to identify elite players.

Reference [6] found, through keyword information analysis, that internet-of-things (IoT) technology has been widely used in high-level sports and the leisure industry. For example, [7] proposed an IoT architecture incorporating embedded sensors, telecommunication technologies, and cloud computing for a football application with the goal of improving athlete health and preventing accidents. Reference [8] utilised strain gauge (SG) sensors, a 3-axis accelerometer and a 3-axis gyroscope to analyse golf swings. The data was transmitted to a laboratory for analysis by the wearable sensors, where feedback could be given to correct the athlete's swing. Reference [9] studied the hand movement of shooters during target training, correlating features of the biofeedback data to successful shots. The research defined a number of basic system architectures of biofeedback that are used in a wide range of sporting applications.

Reference [10] used bivariate Poisson models to analyse large data sets for sports involving two competing teams. They presented a feasibility analysis of the model using data sets from football and water polo, demonstrating an improved ability to predict the number of draws. Reference [11] examined the potential relationship between athletes and so-called Big Data monitoring, discussing privacy concerns and the impact of quantification on the athlete. Reference [12] proposed smart clothes, connected through the mobile Internet, for continuous health monitoring via various physiological indicators to obtain medical Big Data. The clothing aimed to solve the problems of long-term wearer discomfort and insufficient precision of traditional wearable sensor devices. Reference [13] used GPS to track the amount, speed, type, and value of movements, and to present new opportunities and challenges behind Big Data perspectives and results.

In order to improve the performance of rowers, this study presents a two-stage athlete selection model, including a selection hierarchy within the first stage. Based on foreign and domestic rowing literature and the professional abilities required by rowing athletes, experts and scholars in the rowing field are invited to determine the selection index by the modified Delphi method. In the second stage, the Analytic Hierarchy Process (AHP) is used to select the ranking criteria for athletes and provide the basis for the selection of national teams.

II. LITERATURE REVIEW

A. TALENT IDENTIFICATION

Talent identification combines professional experience and scientific methods; involving a series of steps such as long-term observations, training and selection [14]. It assesses the potential of athletes according to the characteristics required by different sports. Through scientific prediction and testing, athletes who have superior congenital and acquired traits are selected and further cultivated [15], [16].

Currently, the empirical judgement of experts and scientific methods are two conventional strategies for sports talent identification. The former involves using the experts own personal experience to conduct simple and rough talent identification. The latter offers a better success rate for talent identification, involving the establishment of criteria for talent identification through scientific investigation [4], [17]–[19].

Reference [20] noted that scientific talent selection is considered as a combination of many sports-related disciplines including; body shape, physiological functions and physical fitness (covered by sport physiology); sports abilities encompassing technique and movements (covered by sports biomechanics); and various psychological qualities and mental abilities (in the field of sport psychology). Reference [20] further added that all of these can be used for the effective evaluation of an athletes' performance and are closely related to genetics.

Physical and mental qualities as well as technique are the three key elements of sporting performance. During competition, the athletes' psychological and emotional state is an important factor affecting their performance [21]. Mental factors often play a determinative role in competitions, particularly when there are only small differences between the athletes' physical qualities and technique.

Inasmuch as each sport has its own characteristics, the requirements of athletes' technique and physiques vary between sports. Reference [22] believed that scientific talent identification was a process in which athletes with congenital traits suitable for a certain sport are selected and systematically cultivated. Continuous monitoring and scientific testing of objective indicators can then provide comprehensive evaluation as well as predictions to aid athlete development.

B. TALENT IDENTIFICATION FOR ROWING

Each sport employs different standards for identifying talented athletes. When carrying out a scientific selection process, athletes in different sports are evaluated according to characteristics of that sport.

Rowing is a sport in which one or more athletes (scullers) sit in the boat facing toward the stern, and use oars to propel the boat forward (toward bow). As a result, proper rowing technique involves the harmonization of muscle exertion from the legs, back, shoulders, and arms as well as coordinated movement between the athletes and the boat [23]. Rowing propulsion is a cyclic action that can be divided into four stages: catch (or entry), drive, release and recovery (or finish) [24]. A variety of skills are required for the different stages, but each stage is closely linked. Moreover, stroke distance, stroke rhythm, stroke tempo, stroke power, and the control of stroke technique can be utilised as important criteria to evaluate the skills of a rower [25], [26]. In order to maximize the speed of the boat rowers have to perform quick leg presses while inclining the torso toward the bow of the boat, before finally pulling their arms toward their chest during the drive [27].

The propulsive force responsible for moving the boat forward depends largely on the power generated through the upper limbs pulling the oars toward the body. However, this pulling power is heavily influenced by the lower limbs pushing on the foot stretcher to generate a reaction force that causes the upper body to rock back toward the bow. Therefore, the source of the power during the drive stage mainly comes from powerful leg pressing [28], [29]. As such, the rowing speed depends on the leg-pressing power the rower is able to generate and how they deliver this power to the upper limbs [30]. During a rowing competition, the rower needs to repeatedly stroke between 220 and 250 times for a 2,000-meter race distance. Therefore, the flexibility of the joints between muscle groups is essential, allowing muscle groups to function properly for the entire race. In addition to coordinating muscle groups, the stroke rhythm plays a key role in determining the stroke rate and the number of strokes required during a race.

A rowing competition requires crews to complete the specific race distance as quickly as possible through applying the strength and muscle endurance of their entire body [31]. Accordingly, the higher the stoke rate and the greater the power output per stroke, the faster and further the boat glides [32]. Rowing is considered to require strength, speed, endurance, and the coordination of muscles throughout the whole body [2], [33]. As a result, the performance of a rower is directly influenced by their technique, muscular fitness (muscular strength and muscular endurance), cardiovascular endurance and explosive strength [34]–[36]. In terms of the rower's physique, greater height (sitting and standing), wider shoulders, longer arms, and higher muscle density are all conducive to rowing performance [28], [37]. With regard to training, both on-water and land training (off-water training or dry training) are utilised. Rowing ergometers (for measuring the power generated by a rower) are usually employed in land training as well as strength and aerobic training to improve strength, endurance and speed [38]. The rowing ergometer is mainly used to emulate the rowing action on water. However, muscle strength, cardiopulmonary function and explosive strength can also be trained through the rowing ergometer.

After a comprehensive review of literature on the identification of talent in general and rowing talent in particular, this study firstly compiled four main criteria and sixteen sub-criteria. These were: 1) physicality, including body composition, muscle composition, sitting height, and shoulder width; 2) reactions, including explosive strength, coordination, speed, and muscle endurance; 3) professional abilities, including flexibility, sense of rhythm, strength of pulling sculls, and leg pressing strength; and 4) mental qualities, including pressure resistance, concentration, confidence, and goal setting.

III. RESEARCH METHODOLOGY

The research methods adopted in this study were the modified Delphi method and Fuzzy AHP, which were carried out in two stages. In the first stage, relevant literature was collected and sorted in order to form a modified Delphi questionnaire for the rowing experts and scholars to review. The important indicators for the identification of talented rowers were then compiled. In the second stage, a formal framework of Fuzzy AHP was established according to the compiled indicators, which was classified into main criteria and sub-criteria. Subsequently, the importance of each criterion was evaluated by utilising the Fuzzy AHP questionnaire to obtain their individual weighting values. The results could then be used to evaluate elite rowing athletes.

The modified Delphi questionnaire aims to establish a consensus between experts' and scholars' on the criteria used for rowing talent identification. The Fuzzy AHP questionnaire further proceeds to conduct a more professional evaluation, obtaining the weighting value for each criterion from experts' and scholars' after testing the consistency of their opinions. The research process is shown in Fig. 1.

A. MODIFIED DELPHI METHOD QUESTIONNAIRE

Reference [39] proposed the modified Delphi method, attempting to improve the traditional Delphi method that is time-consuming and difficult to control the progress toward a consensus. In order to save time and allow the experts and scholars to focus on the research topic, the modified method establishes a structured questionnaire through the literature review and in-depth interview. The modified method replaces the traditional approach that collects and sorts experts' opinions and suggestions before forming the questionnaire.

According to the comprehensive literature review, the criteria for the identification of rowing talent were sorted and further developed as a structured questionnaire. A two-round questionnaire survey was executed, inviting the experts and scholars to answer and/or provide suggestions on specific issues. The opinions of all experts and scholars are integrated to form a consensus.

The modified Delphi method questionnaire adopts the seven-point Likert-Scale to assess every item: 7 means strongly agree; 6 means agree; 5 means slightly agree;

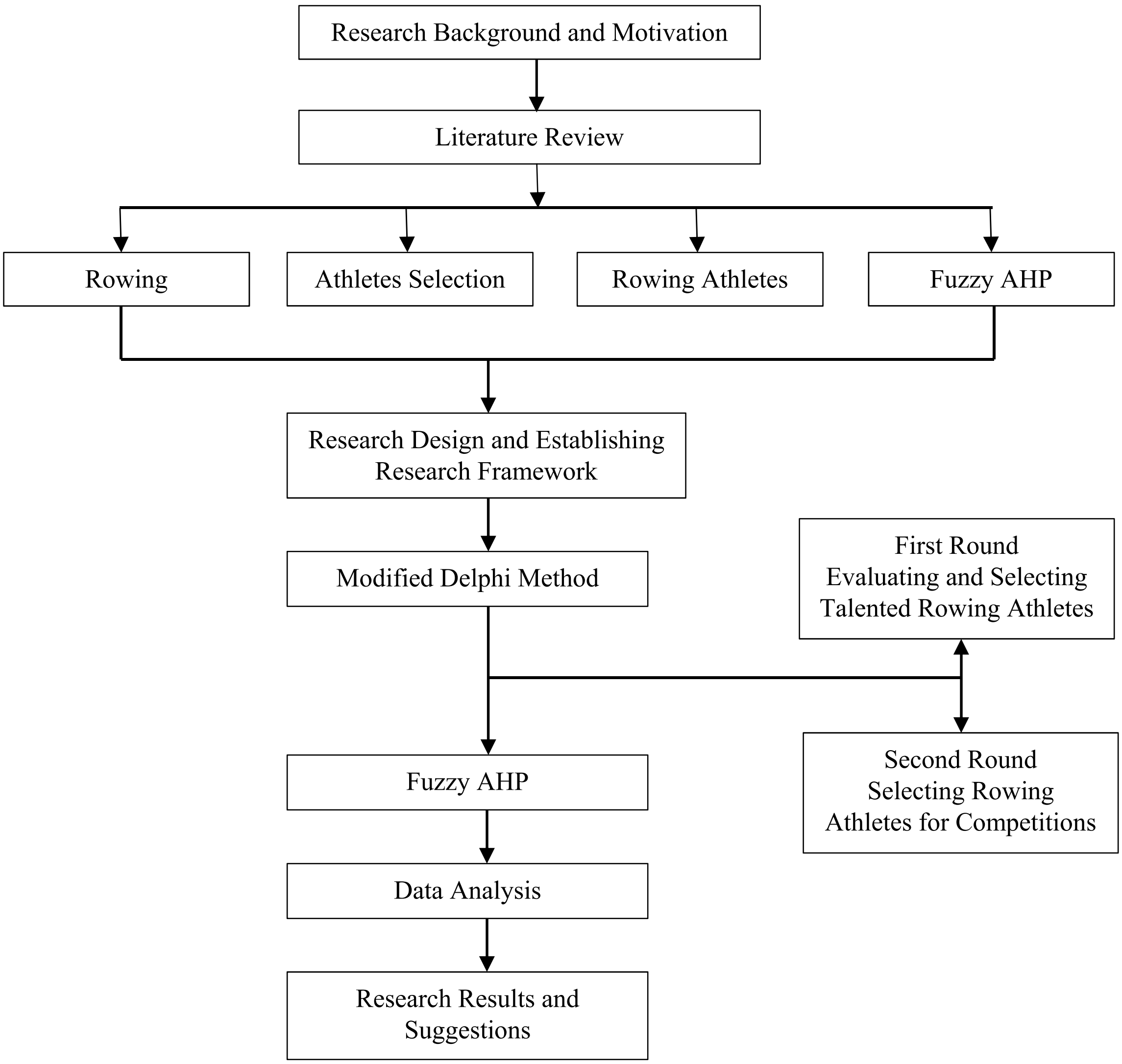

FIGURE 1. Research process.

4 means no opinion; 3 means slightly disagree; 2 means disagree; and 1 means strongly disagree. Moreover, there is also an open-ended item – other suggestions – for experts and scholars to express their opinions on the criteria or to propose additional criteria. A sample of the questionnaire is shown in Table 1:

B. THE FUZZY AHP QUESTIONNAIRE

The implementation process of Fuzzy AHP is basically as the same as that of traditional AHP [40]–[42], with the former including procedures for defuzzification and normalization. Traditional AHP ignores the fuzziness and uncertainty of human evaluation and judgment, but fuzzy AHP integrated with fuzzy theory can address this shortcoming [43].

Based on the research motivation, the framework of this study was proposed after the review and discussion of relevant literature. The complicated problem of rowing talent identification was hierarchized through the Fuzzy AHP into a clear three-layer hierarchical structure. The first layer (A) is the primary goal – the identification of rowing talent – which was analysed through the other layers. The second layer (B) are the key factors or criteria influencing the identification of rowing talent, including four important analytical dimensions – physicality, reactions, professional ability and mental quality – denoted as B1 to B4. The third layer (C) is the extension or sub-criteria of the four key criteria, consisting of sixteen items ranging from C1 to C16. The structural diagram of the Fuzzy AHP is shown in Fig. 2.

C. ATHLETE SELECTION ALGORITHM

Each participating expert selected pairs of indicators for relative comparison and assigned relative scores. The calculation procedure was as follows [44]:

Step 1: Establish a pairwise comparison matrix.

For a set of criteria, the quantitative importance judgment of the pairwise criterion (C_i, C_j) can be expressed as $n\times n$

TABLE 1. **Sample of the modified Delphi method questionnaire.**

The following physical attributes are of high priority for elite rowers. Rate your agreement.

Physicality	Strongly Agree 7	Agree 6	Slightly Agree 5	No Opinion 4	Slightly Disagree 3	Disagree 2	Strongly Disagree 1
BMI							
Muscle composition							
Sitting height							
Shoulder width							

Other suggestion:

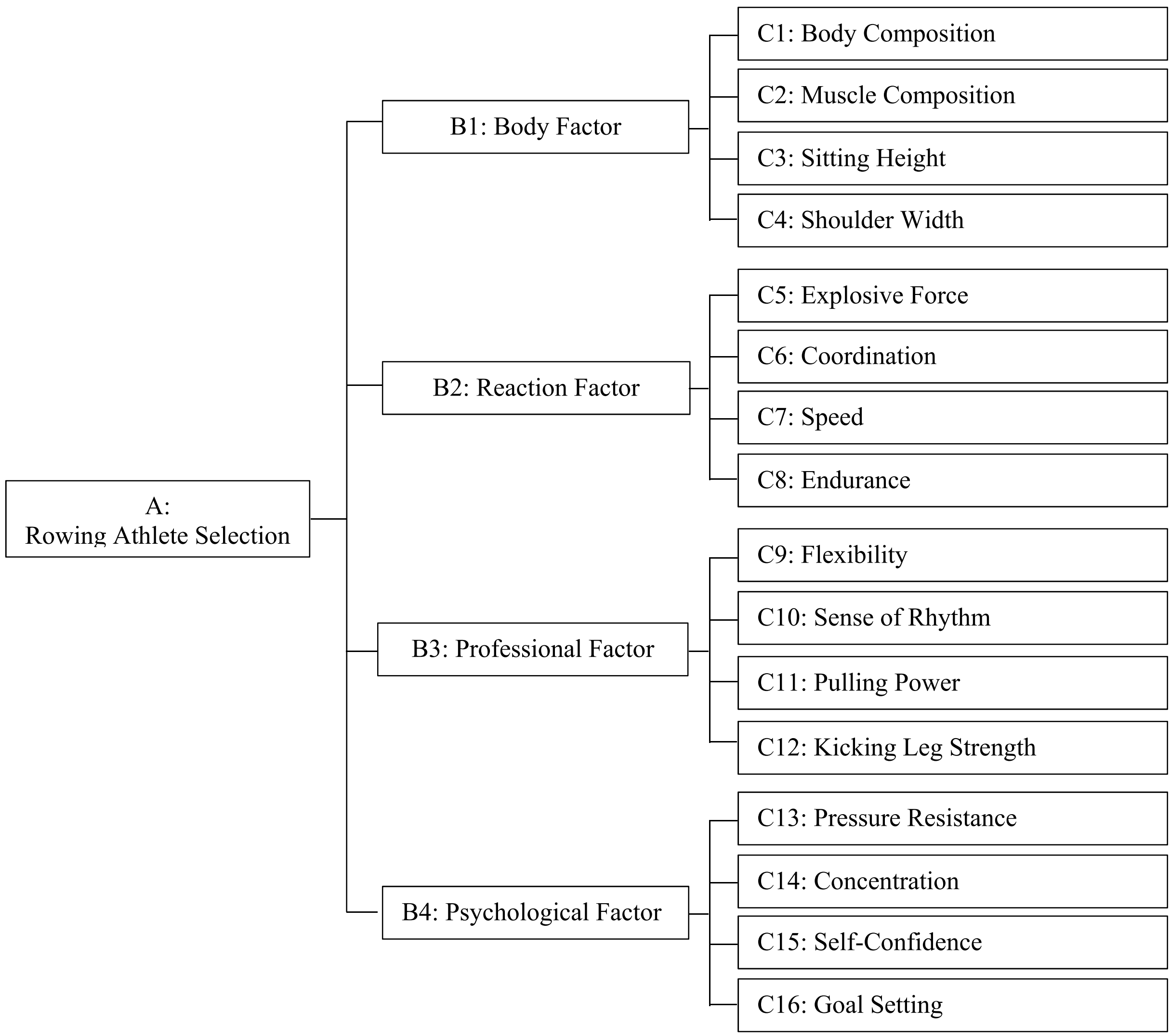

FIGURE 2. **Rowing athlete selection hierarchy diagram.**

TABLE 2. Definition of criteria and sub-criteria and supporting literature.

Criteria	Sub-criteria	Reference
Body Factor	Body Composition	[33], [37]
	Muscle Composition	[26], [31], [33], [35]
	Sitting Height	[33], [37], [46]
	Shoulder Width	[37], [46]
Reaction Factor	Explosive Force	[26], [29], [33], [47]
	Coordination	[26], [48]
	Speed	[25], [38], [47], [49], [50]
	Endurance	[2], [31], [33], [47], [49]
Professional Factor	Flexibility	[51]
	Sense of Rhythm	[26]
	Pulling Power	[25], [29], [49]
	Kicking Leg Strength	[33], [48]
Psychological Factor	Pressure Resistance	[52], [53], [54]
	Concentration	[52], [54], [55], [56], [57]
	Self-Confidence	[54], [55], [56], [57], [58]
	Goal Setting	[52], [54], [58]

TABLE 3. Expert background.

Expert Category	Number	Background
Rowing Expert	6	Athletes and coaches with 7 to 10 years of practical rowing experience
Academic Expert	2	Rowing team coaches with more than 5 years of experience
Government Officials	2	Experts and scholars with 5 to 10 years of professional knowledge in rowing and services in public institutions
Total	10	

matrix ***A*** as follows:

$$\mathbf{A} = [a_{ij}] = \begin{array}{c} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \cdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \vdots & 1 \end{bmatrix} \end{array}$$

where $a_{ji} = 1/a_{ij}, i \neq j$ and $a_{ij} = 1, i = j, j = 1, 2, \ldots, n$.

Step 2: Calculate eigenvalues and eigenvectors.

A is a pairwise comparison matrix, which is the maximum eigenvalue of A. If ***A*** is a consistency matrix, the eigenvector can be calculated using (1).

$$(A - \lambda_{max} I) x = 0 \tag{1}$$

Step 3: Consistency verification

Saaty [44] proposed the consistency index (CI) to measure the consistency of the pairwise comparison matrix ***A***. The consistency index is calculated as shown in (2).

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{2}$$

The consistency ratio (CR) is then calculated as shown in (3).

$$CR = \frac{CI}{RI} \tag{3}$$

where *RI* is a random index.

If CR $\leqq$ 0.1, then the pairwise comparison array ***A*** is considered to be consistent, or have an acceptable degree of inconsistency; otherwise, the pairwise comparison matrix ***A*** is adjusted until consistency is reached.

Step 4: Ranking criteria for selecting the best Rowers based on the CR.

IV. CONSTRUCTING A TWO-STAGE ROWING ATHLETE SELECTION MODEL

This study constructed a new selection model for rowing athletes. The first stage was to establish a hierarchical structure. This stage used the modified Delphi method to determine the criteria and sub-criteria for selection via three steps [39], [45]. Step 1) define the selection criteria for rowing; Step 2) form the team of rowing experts and; Step 3) questionnaire survey of rowing experts and consistency check. The second stage utilised the Fuzzy AHP method to determine the optimal sorting criteria through five steps [44]. Step 1) establish a pairwise comparison matrix; Step 2) calculate the eigenvalues

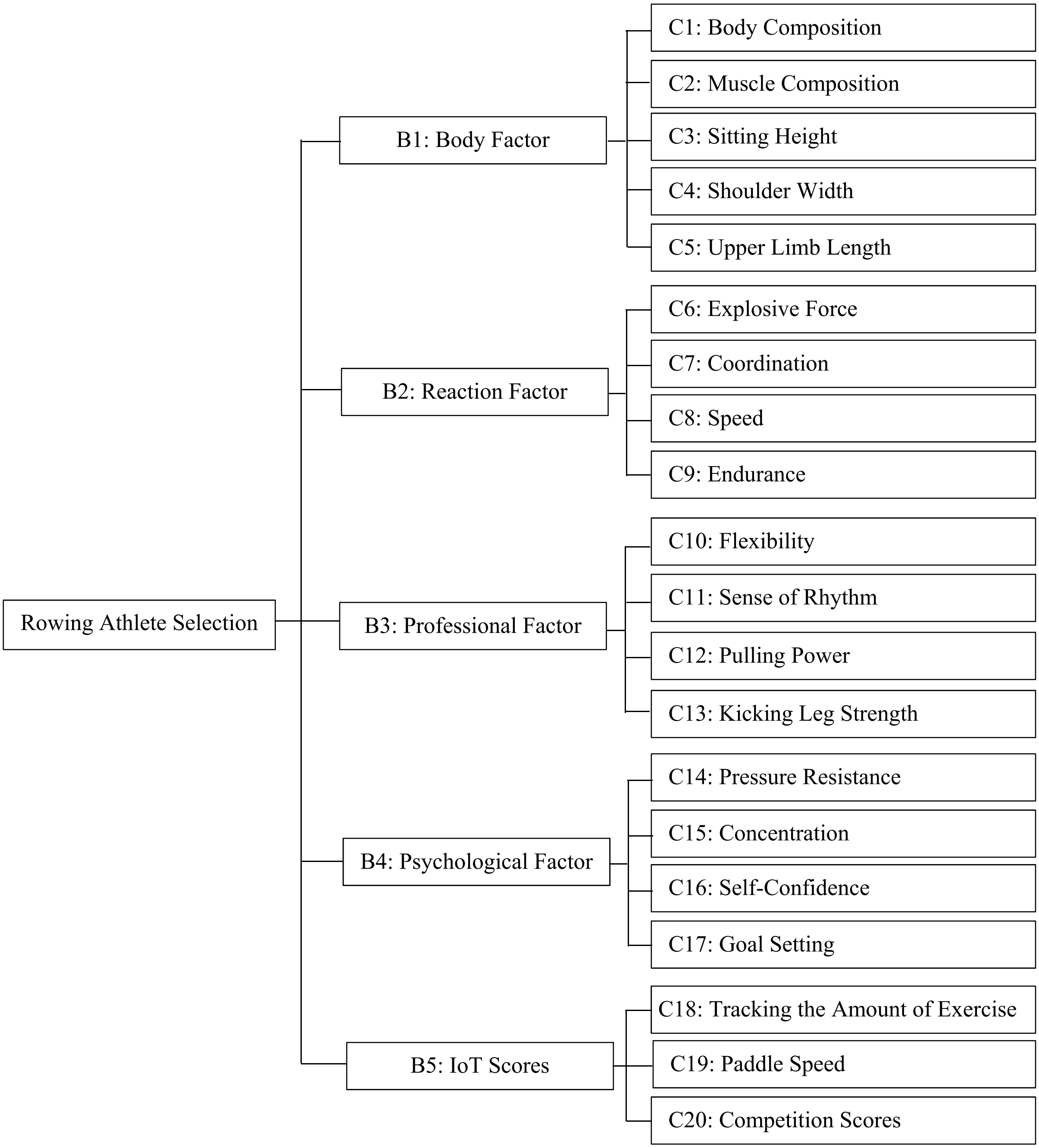

FIGURE 3. **Complete rowing athlete selection diagram.**

and eigenvectors; Step 3) consistency check; Step 4) calculate guidelines and sub-criteria weights; and Step 5) selection of the best guidelines for elite rowers. The evaluation method was conducted as follows:

The first stage involved constructing the athlete selection criteria hierarchy.

Step 1: Define the selection criteria for rowing.

From rowing experts and related literature, the four factors of body elements, reaction elements, professional elements and psychological elements are selected; encompassing 16 selection criteria as shown in Table 2.

Step 2: Composition of the expert group on rowing.

References [59], [60] advocated that there should be no upper limit for the number of experts, but at least 10 experts should be involved continuously. Therefore, 10 experts with 5 to 20 years of practical experience and expertise in the field of rowing were selected to participate in two rounds of modified Delphi method interviews. The composition of experts is shown in Table 3.

Step 3: Expert questionnaire survey and consistency check.

For the first trial, 10 questionnaires were issued, and the recovery rate was 100%. In the first round, the literature

TABLE 4. Statistics of the first round modified Delphi questionnaire results.

No.	Sub-criteria	Results of the first round		
		Average	Quartile difference	Result
1	Body Composition	6.50	0.5	pass
2	Muscle Composition	6.40	0.5	pass
3	Sitting Height	5.00	1	pass
4	Shoulder Width	4.90	1	pass
5	Explosive Force	5.40	0.5	pass
6	Coordination	5.50	0.5	pass
7	Speed	4.70	0.5	pass
8	Endurance	6.50	0.5	pass
9	Flexibility	4.60	0.5	pass
10	Sense of Rhythm	5.20	0.5	pass
11	Pulling Power	6.10	0.5	pass
12	Kicking Leg Strength	6.70	0.5	pass
13	Pressure Resistance	5.20	1	pass
14	Concentration	5.20	1	pass
15	Self-Confidence	4.90	1	pass
16	Goal Setting	4.80	0.5	pass

TABLE 5. Statistics of the second round modified Delphi questionnaire results.

No	Sub-criteria	Results of the second round		
		Average	Quartile difference	Result
1	Body Composition	6.20	0.5	pass
2	Muscle Composition	6.00	0.5	pass
3	Sitting Height	5.60	0.5	pass
4	Shoulder Width	5.20	0.5	pass
5	Upper Limb Length	5.50	0.5	pass
6	Explosive Force	5.60	0.5	pass
7	Coordination	5.80	0.5	pass
8	Speed	4.90	0.5	pass
9	Endurance	6.80	0	pass
10	Flexibility	5.00	0	pass
11	Sense of Rhythm	5.10	0.5	pass
12	Pulling Power	6.00	0	pass
13	Kicking Leg Strength	6.60	0.5	pass
14	Pressure Resistance	5.30	1	pass
15	Concentration	5.00	1	pass
16	Self-Confidence	4.90	1	pass
17	Goal Setting	4.90	0.5	pass
18	Tracking the Amount of Exercise	4.82	0.5	pass
19	Paddle Speed	4.91	1	pass
20	Competition Scores	4.93	1	pass

was used to identify 16 sub-criteria (within the 4 primary criteria) for investigation. The seven-point Likert scale (7 is very important, 1 is very unimportant) was used to assess the criteria, with the responses analysed by quartiles. If the experts assign a criteria a score of 4 or more on average it is considered to be important; if the quartile difference is less than or equal to 0.60, the expert opinions are considered to be highly consistent. If the quartile difference is greater than 1.00, there is considered to be no consensus on the opinions. Therefore, if the interquartile range is greater than 1 and the average is less than 4, the expert opinions have not reached agreement and the criterion is deleted. The 16 criteria that were verified to achieve consensus are shown in Table 4. Finally, at the end of the first round, the participating experts decided to add upper limb length as a sub-criterion under body factor criterion, and an IoT criterion. Within the IoT criterion, there are 3 sub-criteria for tracking the amount of exercise, paddle speed, and the competition scores.

In the second round, the 5 criteria and 20 sub-criteria obtained from the expert opinions in the first round

TABLE 6. Assessment of the rower selection criteria and sub-criteria by weights and rankings.

Criteria	Code	Weights	Rank	Sub-criteria	Code	Weights	Rank
Body Factor	B1	0.343	1	Body Composition	C1	0.226	1
				Muscle Composition	C2	0.170	2
				Sitting Height	C3	0.086	5
				Shoulder Width	C4	0.020	11
				Upper Limb Length	C5	0.028	8
Reaction Factor	B2	0.090	4	Explosive Force	C6	0.006	17
				Coordination	C7	0.020	12
				Speed	C8	0.006	18
				Endurance	C9	0.007	16
Professional Factor	B3	0.244	3	Flexibility	C10	0.016	13
				Sense of Rhythm	C11	0.021	10
				Pulling Power	C12	0.032	7
				Kicking Leg Strength	C13	0.069	6
Psychological Factor	B4	0.037	5	Pressure Resistance	C14	0.015	14
				Concentration	C15	0.009	15
				Self-Confidence	C16	0.004	19
				Goal Setting	C17	0.002	20
IoT	B5	0.286	2	Tracking the Amount of Exercise	C18	0.027	9
				Paddle Speed	C19	0.089	4
				Competition Scores	C20	0.147	3

were re-assessed. The statistical results are shown in Table 5. The results were then converted into a structured rower selection chart, as shown in Fig. 3.

The second stage involved using the Fuzzy AHP method to select the best rowing athletes.

The results of 10 expert questionnaires were consolidated to establish a pairwise comparison matrix of the primary and secondary criteria. Equation (1) was then used ($CI = 0$, $CR = 0$) to meet the consistency check. Table 6 shows the weights of the criteria and sub-criteria, which are sorted according to the weight values.

According to the calculation results from the Fuzzy AHP, the body factor was ranked first among the primary criteria in Table 6, with a weight value of 0.343. It was proposed by [37] that the rowing athletes are taller. Taller sitting posture, greater shoulder width, longer arms and higher muscle density are beneficial to the performance of rowers. The sub-criteria within the primary criterion of body factor were ordered according to their weights as body composition 0.226, muscle composition 0.170, sitting height 0.086, upper limb length 0.028, and shoulder width 0.02. The IoT primary criterion was ranked second, for which athletes' data is measured by the technology. The ranked order of the sub-criteria within the IoT category is the competition scores 0.147, paddle speed 0.089, and tracking the amount of exercise 0.027. The professional factor was ranked third according to its weight value of 0.244, containing the sub-criteria of kicking leg strength 0.069, pulling power 0.032, sense of rhythm 0.021, and flexibility 0.016. Among these sub-criteria, kicking leg strength had the highest weight value, and [48] and [33] emphasize that the rowing exercise exerts a similar effect on the rower's lower limbs. The reaction factor was ranked fourth of the primary criteria with a weight value of 0.090. The order of the sub-criteria under the reaction factor is coordination 0.006, endurance 0.007, explosive force 0.007, and speed 0.006. The endurance weight was one of the highest within the reaction factor criterion; supporting the conclusions of the study by [49] and [47], which found that rowing required a certain level of endurance. The lowest ranked primary criterion was the Psychological Factor weight value of 0.037, with sub-criteria ordered by pressure resistance 0.015, concentration 0.009, self-confidence 0.004, and goal setting 0.002.

V. CONCLUSION

According to the results of this study, the primary consideration for the selection of rowing athletes is the physical attributes of rowers. Having the advantage of an appropriate body type can make training in the future more effective. Data collected by IoT technology, which monitors the status of athletes continuously, was found to play a key role in the selection of elite rowers. The professional factor is also the important in the selection process (the third consideration). The lower weighting value given to the evaluation of the rower's reaction factors and psychological factors suggest that they are secondary considerations in the selection process.

Through discussion of the literature and a two-round modified Delphi method, combined with the expert opinions, this study concluded that the selection criteria for elite rowers can be divided into five main criteria and 20 sub-criteria as the evaluation indicators. A Fuzzy AHP is then used to access a weight to each criteria and sub-criteria. The rankings of these criteria based on the weight factor can then be used for making selection decisions.

The selection model proposed in this study compares selection criteria for rowing athletes. The research results show that the ''body factor'' criterion is the most important selection indicator, followed by the ''IoT'' criterion. An athlete with a naturally appropriate body type has an advantage that is unobtainable by athletes of other body types. To then separate athletes of this body type, monitoring through the use of IoT technology for the Big Data analysis, can provide more objective measures for the selection process.

A future extension to this research could include more detailed criteria and sub-criteria to construct and evaluate selection indicators for specific rowing events or related sports. In addition, including more evaluation methods to analyse the data would further improve the objectivity of the ultimate selection decisions.

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JING-WEI LIU is currently an Associate Professor with the Department of Sport Information and Communication, National Taiwan University of Sport. He specializes in virtual reality, augmented reality, game-based learning, big data, fuzzy time series, data mining, soft computing, and artificial intelligence. His article appeared in *Computers & Education*, *Computers and Mathematics with Applications*, *Economic Modelling*, the *Journal of Computer Information Systems*, the *International Journal of Information and Management Sciences*, *Plant Systematics and Evolution*, *Expert Systems with Applications*, *Advanced Materials Research*, the *Open Journal of Social Sciences*, and so on.

SHENG-HSIANG CHEN received the B.S. degree in physical education from National Kaohsiung Normal University, Taiwan, in 2006, the M.S. degree in sports management from the National Taiwan University of Sport, Taichung, Taiwan, in 2008, and the Ph.D. degree in sociology of sport from Loughborough University, U.K., in 2015.

He is currently an Assistant Professor with the Department of Sport Information and Communication, National Taiwan University of Sport. His research interests include sociology of sport, sport policy analysis, sport management, and sport marketing. His articles mainly appeared in *Physical Education journal*, the *International Journal of Contemporary Hospitality Management*, the *Quarterly of Chinese Physical Education*, the *Journal of Management Practices and Principles*, and so on.

YEN-CHEN HUANG is currently pursuing the degree with the Department of Recreational Sport, National Taiwan University of Sport. She specializes in fuzzy analytic hierarchy, dDelphi, and data Mining. Her article appeared in the *International Journal of Information and Management Sciences*.

CHING-TANG WANG is currently a Professor with the Department of Sport Information and Communication, National Taiwan University of Sport. He specializes in sports facility design and planning, sports events management, sports administration and management, sociology of sport, and training methods. His articles mainly appeared in *Sports Coaching Science*, *National Sports Quarterly*, *Tourism and Hospitality Research*, *Taiwan Architect*, *Pensee journal*, the *International Journal of Asian Tourism Management*, and so on.