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ROWING TALENT IDENTIFICATION BASED ON MAIN AND WEIGHTED CRITERIA FROM THE ANALYTIC HIERARCHY PROCESS (AHP)

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Abstract

A proper device with a scientific approach in sport talent identification leads to rapid detection of competitive sport talents. This enables maximum success and sustainable achievement in sport competition, including rowing. In this field, investigation is mostly based on effective parameter categorization in talent identification or determining elite athlete norms. Creating a smart model in rowing talent identification based on the main and weighted criteria resulted from an analytic hierarchy process (AHP) from anthropometric, biomechanical, psychological, physiological, and technical aspects is the main objective of this study. The AHP decided that the selected parameters include body height and length of legs (anthropometric aspects); leg strength and muscle power (biomechanical aspects); self-confidence and motivation (psychological aspects); aerobic and anaerobic power (physiological aspects), and recovery and drive (technical aspects). This model can be reliable as well as useful in rowing talent identification, particularly for the young population.

Keywords: Analytic hierarchy process, Rowing, Talent identification.

1. Introduction

In sports, talent identification is defined as a process of detecting an ability and later adjusting the skills with the main and effective criteria [1-3]. It is also a method of changing athletes' potential to be a functional condition which needs to be developed by a sports organization or club [4, 5]. An optimum sports talent identification (STI) consists of all important indexes and provides a comprehensive model leading to significant results [6-8].

In the last few years, STI has been implemented by referring to the criterion norms of elite athletes so that athlete candidates' talents will be compared to those of the elite athletes [9]. However, the criteria selected were usually mono-factorial as multi-factorial analyses in STI are complicated [10, 11]. As STI plays an important role in maintaining stable and sustainable success in global sports competition [12], implementing an artificial intelligence (herein referred as to AI) algorithm – based model with big data processing volume and proper interpretation and right decision will be an effective and valid method in STI.

An approach namely Analytic Hierarchy Process (AHP) has been implemented in volleyball measuring such parameters as height and length of the upper extremity (anthropometric), agility and strength (biomechanical), self-confidence and motivation (psychological), special endurance, aerobic and anaerobic (physiological), spike and serve (technical) as the main criteria. The smart model analysed the data by comparing the variables, the elite athlete norms, and athlete candidates' talents. This identification model can be a reliable STI model for volleyball in the future [13]. Scientific selection of badminton players using AHP has also been implemented in Taiwan. With reference to the literature and implementation of AHP, the study analysed and designed a selection model where the coaches finally decided the indicators of the selection.

The proposed model which can be a scientific and objective reference for badminton coaches consists of 5 dimensions including (1) body type: (2) physical condition: (3) physical function); (4) psychological quality); and (5) intelligence level [14]. Some of rowing coaches who have identified their athlete candidates' talents limitedly referred to anthropometric measurement [15] or sometimes based on visual observation and one or two performance predicting parameter for a 2,000 m ergometer rowing [15-18] and on a rowing single-scull in the water [19]. In reality, coaches are struggling with STI as there are a lot of criteria to consider based on the type of sport they coach. A systematic STI procedure is necessary since some coaches lack in having an adequate approach and can sometimes make mistakes.

There have been other sports-related studies implementing AHP [20]; however, very few of them discussed systematic criteria procedure and decision-making using AHP in rowing. This study aims to create a standardized smart model for STI in rowing for athletes aged from 16 to 18 years old. In this study, the main criteria used are anthropometric, biomechanical, psychological, physiological, and technical aspects selected by AHP based on their effectiveness. Experts' points of view regarding STI using AHP are collected through a questionnaire which later is analysed using Expert Choice software.

2. Literature Review

2.1. Talent identification in sports

Talent identification (TI) is such a big business that it covers various areas including sport, arts, and education. Researchers from different domains have made efforts to identify the best among the best within their field. However, discovering the most effective and efficient talent identification is a complex task, despite its popularity which has drawn a lot of attention lately [21]. In the late 1960s and the beginning of 1970s, there are a lot of eastern European countries realizing the weaknesses of traditional IT programs and attempting to develop new methods supported by scientific theories and proof [22]. Human Kinetics publishers. The results were quite astonishing; in Bulgaria, for instance, 80% of the gold medallists were actually the results of a comprehensive TI process. In the meantime, Romanian and Eastern German athletes in 1972, 1976, and 1980 gained back success due to their scientific selection adopted in the late 1960s [22]. In such other domains as dancing [23], arts [24], and education [25], it has also been proven that talent identification which has been often omitted usually leads to lack of potential.

A traditional sports talent identification (STI) procedure is categorized by several authors as a "natural selection" [22], as those identified are individuals who have been already involved in sports. The sport involvement is possibly due to pressure from peers and parents, and facilities or popularity of sport within the geographical area so that it is such a coincidence that individuals choosing a certain sport appear to be outstanding. Unfortunately, while Eastern European started to leave a traditional approach, the Western seems to still implements it. This initiative; however, aims to adopt more scientific selection process. Using a scientific approach identifying criteria by athletes, musicians, and elite artists combined with optimal environments maintaining the quality of the criteria, we believe that we tend to create more high-achieving players. Individuals with right psychobiological criteria can actually be introduced to a new sport they possibly did not know before [22], which leads to the improvement of success. This kind of procedure aims to identify elite player candidates currently not involved within the targeted sports; it is also commonly known as talent detection. One of the advantages of scientific approach is its objectivity. Coaches have been usually detecting talents; however, their process, even though it cannot be taken for granted, is subjective [26]. In addition, individuals should have been accepting a certain training or skills to be able to be observed by the assigned talent scouters. It is certainly noted that identifying individuals' talent to show fundamental/ basic skills means that their current accomplishments are identifiable [23], and consequently, finding the desired skills and talents are important [26]. A pursuit of excellence model [26], highlights talents and potential to develop. In the meantime, a traditional method relies on natural selection, implements two TI models, and almost neglects talent scouting phase [26].

The current debate underlines the importance of combining talent scouting and development [27], even though it is widely believed that talent is gifted and genetic factors play a secondary role supported by positive environment. Oxford Learner's Dictionary of Academic English defines talent as a natural ability to do something well or in which people perform, to show how well they can sing, dance, etc. However, the belief that talent is a gift implies that it is predetermined and relatively stable; on the other hand, it cannot be developed and that environment can actually

omitted [21]. Talent identification in sports is a process of detecting skills to later be the main and effective criteria needed in a certain type of sport [1], while talent selection is the first phase of sports coaching. In order to be able to reach perfect performance, natural talent should be able to be identified in addition to a scientific approach. Early trainings usually lead to good results [14]. Talent identification and development (TID) system is usually used in professional sports to transform young athletes into future stars [1, 26]. Talent identification is a method of changing athletes' potential into a functional circumstance to be developed by sports clubs and organizations [4, 5].

2.2. Talent identification using Analytic Hierarchy Process

A decision-making method using AHP was firstly developed in 1980 by Thomas L. Saaty at the University of Pittsburgh, the US and in 1971 was published in his book entitled Analytic Hierarchy Process [28]. In 1980, AHP was more complete [28, 29]. AHP is a process of decision-making using pairwise comparisons to explain evaluation factors and quality factors in a multifactorial condition. Therefore, AHP is used when the decisions made involving several factors, where it finds difficulty in making the quality of each factor selected.

The contents of AHP aim to systematically develop problem hierarchies. Pairwise comparisons are able to determine the relative quality of each element and enhance the planned ranks as a reference to choose the best plan [29]. The purpose of AHP is to create a complex system and organize data, thoughts, and intuitive assessments through the logic and structure of hierarchy. For decision makers, hierarchical structure also helps understand and break down complex and non-structured problems so that hierarchy is built. The values are based on the importance of variables and determined through subjective evaluation. After a series of evaluations and statistical computations have been performed, variable ranking proceeds to result in good decision-making [14, 30].

In global economy, commercial organizations and modern industries need to develop better methods to evaluate their human resources' performance rather than just using performance measurement such as efficiency and effectiveness. When an organization looks for an aggressive way to cut the cost and improve global competition, maintaining their employees' performance is important. This is closely related to decision-making among several factors. In a certain time, companies would show characteristics with their key factors of competence as it also applies in the process of TID of young athletes with complex problems and multi-dimension enforcing the use of multivariate approaches. Consequently, technical, tactical, and psychological factors should also be considered in addition to anthropometric and physiological approaches [31]. In another context, this type of procedure also applies when a certain club coach identifies their players and decide whether to group their them in their squad or in their starting line-up [32]. In sports, the processes of player selection and team forming are a complex multi-criteria issue where their success is determined by how a collection of players make an effective team [33, 34]; for instance, selecting starting pitchers is a strategic issue with a significant effect on the performance of a professional team [35], evaluating the performance of football teams in the German Bundesliga [36], selecting learning models of physical education [37, 38] and determining criteria of successful players in a golf tournament [39].

3. Methods

Mixed methods research (MMR) involves the use of both quantitative and qualitative methods within a study. It is believed that this type of method gives clearer and more complete understanding in comparison with partial use of each method [2]. Even though MMR has emerged since 1950s, studies with this method on sports science started to get significantly implemented in 2005 [40]. MMR is commonly used to cope with weaknesses of either qualitative or quantitative approach in sports-related studies [41] as it aims to combine both quantitative and qualitative methods in order to create a product giving significant contributions to sports science research [41-43]. In this study, MMR was used to create a device identifying rowing athletes' talents. There were three different approaches used namely discussion with national rowing coaches, development of a software of talent identification designed by AHP analysis – based simulation approach and Fuzzy Logic, and device trial using an experimental approach.

Discussion was carried out in order to acquire information related to important criteria of rowing athletes' talent identification in accordance with the Olympics standards. Due to the global pandemic of COVID-19, the discussion was administered through questionnaires distributed online through Google Form. The informants were asked to fill in the criteria priority based on anthropometric, physiological, biomechanical, technical, and psychological aspects. Those criteria were purposively selected with reference to multi-perspectives on international rowing athletes' talent identification. The model was also equipped with 22 sub-criteria directly affecting the ranking process. The selection of both the criteria and sub-criteria was supported by a variety of references from credible resources. The description of the criteria, sub-criteria, and reference resources are shown in Table 1.

Table 1. Criteria and sub-criteria selected for evaluation of rowing athletes' evaluation.

Criteria	Sub-Criteria	Code	Description	Reference
Anthropometric aspect	Weight	ANT1	Weight refers to body weight measured with minimum clothing without any other equipment. Weight is measured using a scale with kilogram.	[44-49]
	Height	ANT2	Height is an anthropometrical measurement describing skeletal growth	[44-49]
	Length of legs	ANT3	Legs lengths ranges from palm of the foot to the trocantor nayor, approximately on the outer bone of the thigh. When moving, trocantor nayor can be touched on the upper part of the moving thigh bone.	[44-48]
	Arm span	ANT4	Arm span ranges from the tip of fingers of the left hand to	[44-48]

			that of the right hand when they are stretched out 90° in line with the shoulders. This result of this measurement is usually close to that of body height.	
	Sitting height	ANT5	Sitting heights measures vertical distance from the one's sitting surface area to their top of the head.	[22, 48]
	Shoulder width	ANT6	This width measures the horizontal distance between the sitting height position and upper arm tightly close to the body	[22, 48]
	IMT (BMT)	ANT7	Body Mass Index (BMI) or IMT (Indeks Massa Tubuh) in Indonesian language indicates whether one's body weight is normal, ideal, overweight, obese, etc.	[48-50]
	Body fat	ANT8	The percentage of body fat is that of the total body fact towards the body weight. In this study, the percentage of body fat is measured through an anthropometric measurement of body fact accumulated under the skin known as subcutaneous fat.	[48-50]
Physiological aspect	Aerobic	PHY1	Aerobic capacity is defined as an ability of heart and lungs to release oxygen to the muscles. One of the examples is the ability of the body to take and use oxygen to increase aerobic performance.	[45, 47, 50-53]
	Anaerobic	PHY2	Anaerobic capacity is the total energy from anaerobic energy system (without oxygen), which is the number of output of ATP, phosphocreatine, and lactate acid.	[45, 47, 50-53]
	Aerobic power	PHY3	Aerobic power is measured as the highest position where oxygen is taken and used by the body during maximum training. It can also be	[45, 47, 50-53]

			defined as maximal oxygen uptake (VO2max).	
	Vital capacity	PHY4	Vital capacity is the maximum air volume going in and out of the lungs. It is also defined as backup volume of respiratory reserves added by tidal volume.	[22]
Biomechanical aspect	Legs strength	BIO1	Legs strength is one's ability to use the maximum strength of the leg muscles within a short time period.	[45, 50, 52-55]
	Arm strength	BIO2	Arm strength is one's ability to use the maximum strength of the arm muscles within a short time period.	[45, 50, 52-55]
	Muscle Power	BIO3	This type of power is defined as an ability to perform a task. Power is measured and reported specifically in such measurements as horsepower, watts, ft.-lbs./min, kgm/min, and kilocalories/min.	[45, 50, 52-55]
Technical aspect	Catch	TEK1	Catch is placement of the paddle leaf in the water on recovery. This is also the initial moment of connection between rowers and water, and connection between the rowers' strength to the boat on the initial drive.	[50, 52]
	Drive	TEK2	Drive is the phase from catch to extraction. When the paddle leaf is placed in the water in catch, rowers start to lift up the boat passing the blade by straightening up their legs/ legss, while their body keeps leaning forward and their arms are straight. This technique is called drive.	[50, 52]
	Recovery	TEK3	Recovery is a part of stroke when rowers leave their boats moving and ready for the next stroke. This happens when the paddle leaf is out of the water; starting from the	[50, 52]

			moment the paddle leaf is extracted from the water to when it is placed back into the water in catch.	
Psychological aspect	Self-confidence	PSI1	Self-confidence is convincing one's ability and judgment in doing a task a selecting an effective approach. This includes one's self-confidence in facing more challenging situations.	[50, 52, 56]
	Motivation	PSI2	Motivation is a strong desire, drive, or talent within one's self to obtain a certain goal. The presence of motivation will encourage them to reach what they aim.	[50, 52, 56]
	Focus	PSI3	This is an ability to concentrate on and increase sensitivity on one object without adding other distracting objects.	[50, 52, 56]
	Resistant to fatigue and stress	PSI4	Endurance to stress in this study is an ability to fight against threatening stressors. This is reflected through their resistance towards stress, either in a physiological or psychological form.	[50, 52, 56]

Data were collected through an opinion poll to 30 local and national coaches from Papua, Sulawesi, Java, Sumatera, and Kalimantan (Borneo). Their various span of coaching experiences varying from one to five years also reflects their diversity. In addition, their difference in coaching experience level (local and national) also gives different perspectives and opinions. Even though this sample is not used for statistical analysis, it offers important guidelines related to their experiences in participating in educational training, coaching experiences, and making the best achievements which are proven to influence their opinions and responses.

An AHP approach for multi-criteria analysis (MCDA) was adopted in this study as the approach for the following reasons (i) a complex issue can be decomposed to be a manageable hierarchy; (ii) pair-wise comparison in every level is to make sure a comprehensive investigation; and (iii) single decision output can be reached. A decision-making method using an AHP approach was firstly developed in 1980 by Thomas L. Saaty in his book entitled Hierarchy Process [28]. AHP is a decision-making process using pair-wise comparisons to explain evaluation and quality factors in a multi-factor condition. Thus, AHP is used when decision-making involves several factors, where the process of decision-making experiences difficulties in creating the quality of each factor. Some studies have elaborated the

basic theories of AHP comprehensively [57] and some other studies introduced a variety of models, concepts, and applications of AHP systematically [58].

Moreover, some studies put more focus on the comparison of AHP weight coefficient [59] and analysed the contexts of the main advantages, disadvantages, and improvement possibility of the existing AHP [60]. Some researchers had studied initial combination of Fuzzy Logic and AHP [61] and some others had developed and documented AHP model development well [62-64]. The process in this study was summarized in four stages as follows.

- STAGE 1. Arranging the hierarchy of problems aiming to create talent identification models of Indonesian rowing athletes.
- STAGE 2. Representing the results of opinions of the rowing coaches through numbers.
- STAGE 3. Synthesizing the results in all the hierarchies.
- STAGE 4. Analysing the sensitivity towards the score changes.

In this study, the main criteria such as anthropometric, biomechanical, physiological, psychological, and technical aspects of rowing technique were determined by an analytical hierarchy process (AHP) based on the effectiveness. The relative quality of each element in every hierarchy should be identified one another. This aims to find out the level of preference of decision makers towards the comprehensive hierarchical structure. The first step in element priority determination was performed through pairwise comparisons, in which paired comparisons were done for all the elements in each hierarchical sub-system. The comparisons were then transformed into matrix for numerical analyses. The inter-element comparison within the hierarchy used a one-to-nine scale as presented in Table 2.

Table 2. Scale of evaluation comparison.

Level	Definition	Remarks
1	Both elements are important equally important	Both elements have equally big influences towards the objective
3	One element is slightly less important than the other	Experiences and evaluation fairly support one element rather than the other
5	One element is more important than the other	Experiences and evaluation strongly support one element rather than the other
7	One element is clearly more important than the other	One strong element predominantly supportive is viewed in the practicum
9	One element is absolutely more important than the other	Proof of one element supporting the other has the highest possibly strengthening factor
2, 4, 6, 8	Scores of both are close to each other	This score is given when there is a compromise between two choices
Opposite	If element *j* has a number compared to element *j*, then *j* has the opposite score when compared to element *i*	

The hierarchy model was formulated in four stages. In this study, the top level consisted of the research objective followed by the five main criteria on the second level. Each criterion was widespread into sub-criteria on the third level. The last

level, in the meantime, contained alternatives, which are rowing athlete candidates in this context, which would be evaluated as shown in Fig. 1.

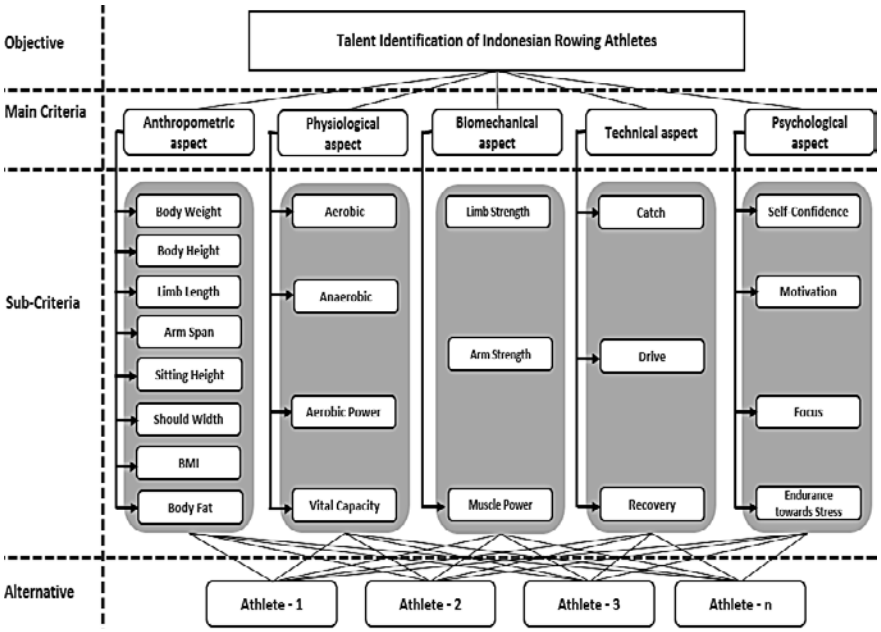

Fig. 1. AHP model of rowing athlete candidate evaluation.

4. Results and Discussion

The example of AHP questionnaire is shown in table 3. For instance, height has a value of three in comparison with body weight which shows that height is slightly more important than body weight (as shown in Table 1). In contrast, body weight compared to height has a value of one third (0.333).

Table 3. AHP questionnaire for determination of criteria importance.

	Body weight	**Body height**	**Length of legs**	**Arm span**	**Sitting height**	**Shoulder width**	**BMI**	**Body fat**
Body weight	1	0,333	0,333	3	3	5	3	9
Body height	3	1	3	3	3	7	3	9
Length of Legs height	3	0,333	1	3	3	5	3	9
Arm span	0,333	0,333	0,333	1	0,333	5	3	9
Sitting height	0,333	0,333	0,333	0,333	1	3	1	7
Shoulder width	0,2	0,14	0,2	0,2	0,333	1	0,333	3
BMI	0,333	0,333	0,333	0,333	1	3	1	7
Body fat	0,111	0,111	0,111	0,111	0,14	0,333	0,14	1

	Aerobic	Anaerobic	Aerobic power	Vital capacity
Aerobic	1	3	1	3
Anaerobic	0,33	1	0,333	3
Aerobic power	1	3	1	3
Vital capacity	0,33	0,33	0,33	1

	Legs strength	Arm strength	Muscle power
Legs strength	1	3	3
Arm strength	0,333	1	1
Muscle power	1	0,333	1

	Catch	Drive	Recovery
Catch	1	3	1
Drive	0,333	1	0,333
Recovery	1	3	1

	Self-confidence	Motivation	Focus	Endurance to stress
Self-confidence	1	1	3	3
Motivation	1	1	3	3
Focus	0,33	0,33	1	1
Resistant to fatigue and stress.	0,33	0,33	1	1

To develop more comprehensive understanding about the priority reported in Fig. 2, comparison of the sub-criteria in each paired criterion based on the experts' opinion is performed. Figure 2 gives the list of priority of eight criteria of anthropometrics (ANT). It has been proven that body height (ANT2) is the most preferred (0.297) in comparison with the other seven criteria: length of legs (ANT3), body weight (ANT1), sitting height (ANT5), arm span (ANT4), BMI (ANT7), shoulder width (ANT6, and body fat percentage (ANT8) which in order have the following score 0.218, 0.165, 0.102, 0.099, 0.72, 0.31, and 0.16. It is then followed by the physiological criteria (FHY) in which aerobic skills (FHY1) and aerobic power (FHY3) are considered mutually important with priority score at 0.368. Meanwhile, the other two criteria, anaerobic skills (FHY2) and anaerobic power (FHY4) are considered the least important with the score at 0.169 and 0.06 respectively.

For biomechanical criteria (BIO), leg muscle sub-criteria (BIO1) is considered the most important aspect with the priority score by 0.6 while arm power and muscle power are the next important aspects with the priority score by 0.2. For catch (TEK1) and recovery (TEK3) sub-criteria, experts mutually give the score of 0.429 and drive sub-criteria (TEK2) is considered the least important. Finally, psychological criteria (PSI), experts give the highest score to both self-confidence (PSI1) and motivation (PS12) sub-criteria with the score of 0.375 followed by focus (PSI3) and resistant to fatigue and stress (PSI4) sub-criteria with the score of 0.125.

The results were analysed by EXPERT CHOICE software and their main and weighted criteria were determined (Fig. 2).

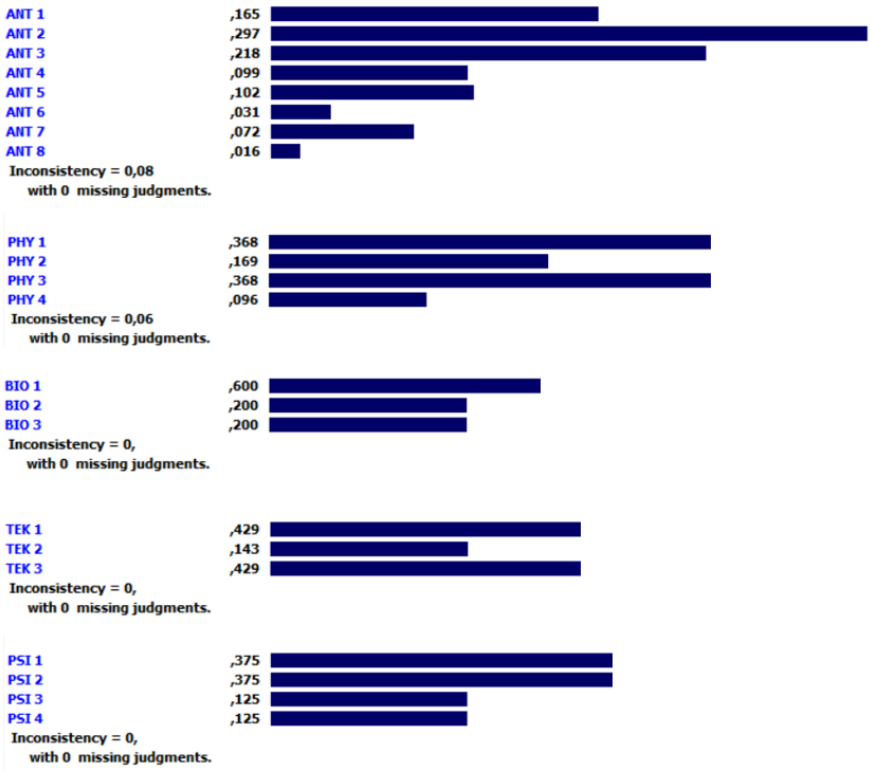

Fig. 2. The determination of main and weighted criteria by AHP method.

A further analysis is performed for each sub-criterion referring to the research purposes. Figure 3 shows that weighted sub-criteria under the technical aspect criteria, which are catch and recovery, mutually have the most important priority with the score of 0.429 followed by aerobic skills and aerobic power with the score under that of physiological criteria (0.81).

The classification of top ten sub-criteria based on the quality includes body height (6.6%), length of legs (4.8%), aerobic (8.1%), aerobic power (8.1%), leg strength (4.3%), muscle power (1.4%), recovery (18.9%), drive (18.9%), motivation (1.7%) and self-confidence (1.7%). The importance of all the ten criteria is by 74.5%.

It is sufficing to say that the most important point in rowing is catch, that is when the blade touches the water. The blade should touch the water before all the power is used to stress (foot stretcher) so that it can reduce negative force to be transferred into the blade. However, no matter how good a rower is, they will always find negative force and decreasing speech once the blade gets into the water. Our main purpose of increasing the technique is to reduce speed change variation. Effects of interaction between positive and negative force will be repeated around 220 to 250 times every 2,000 meters. A slight reduction of speed in each stroke

leads to the reduction of speed average so that each stroke distance is getting lesser. For instance, the reduction of a 5-cm distance in each stroke times the number of stroke is 12.5 meters for each 2,000 meters.

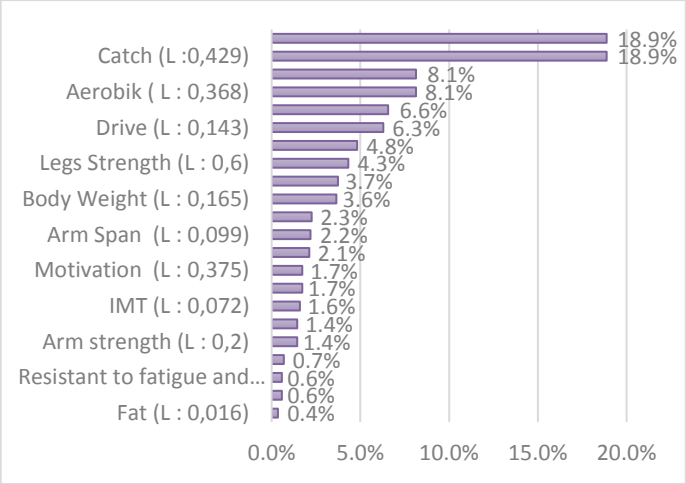

Fig. 3. Sub-criteria priority towards research purposes.

In terms of technical perspective, catch and recovery have been found to be the most important criteria. This tendency shows that rowing does not only require huge physiological and biomechanical skills but also other skills since rowing is like reading, skating, and dancing which require arts. Movements in rowing are done in a rhythmic, continuous, and harmonious way with good ratio of working and resting phase. In short, rowing is an art as well as a science [52]. Meanwhile, in terms of aerobic skills and aerobic power, the time reached for every 2,000-meter stroke ranges from 5 minutes 30 seconds to 8 minutes with stroke frequency between 32 to 42 spm (strokes per minute). Power per stroke of eight elite athletes usually reaches the average of 450 – 550 w (watt) yet sometimes it reaches 1,200 w, especially since the aerobic system provides most energy for race performance [52]. It has also been found that rowing stroke lasting for 6 minutes 43 seconds need 85% aerobic energy and 16% anaerobic energy [65, 66].

The sub-criteria of body fat percentage in terms of anthropometrics are identified as the least important. This means that when the body height and weight are proportional, the body fat percentage can actually be omitted. There is an interesting fact that high-achieving rowers with taller body usually have decreased skin folds [67].

5. Conclusions

Rowing athletes' talent identification scientific selection is a complex issue in Indonesia. Therefore, with reference to literature and AHP, this study analysed and developed a selection model using main indicators and weighted criteria by rowing coaches. There are main criteria including (1) anthropometrics; (2) physiology; (3) biomechanics; (4) technique; and (5) psychology divided into 22 sub-criteria. Ten indicators taken from top two of each criteria are body height and length of legs (anthropometrics), aerobic skills and aerobic power (physiology), legs strength and

muscle power (biomechanics), recovery and drive (technique) are considered the most important criteria and main quality. All the ten indicators reach 74.5%.

Conflict of Interest

This smart model was designed by the authors.

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