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METHOD OF EVALUATION OF MILITARY HELICOPTER PILOT SELECTION CRITERIA: A NOVEL GREY SWARA APPROACH

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Abstract. Helicopter is a very important defence and attack tool for a country's armed forces (army) (air force). With the rapid progress of technology, the designs of helicopters, the hardware and software elements in the helicopter have also been renewed and developed in parallel with advanced technology. Therefore, it is expected that the pilots who will use helicopters, which are an important flight tool of armed forces, will also have the qualifications to provide the necessary knowledge, skills, and criteria. The aim of the study is to determine the military helicopter pilot selection criteria and to find the importance levels of these criteria. For this purpose, three main criteria as "Health", "Psychomotor" and "Education and Training" and thirteen sub-criteria were determined. The weights of the determined criteria were found by the Grey SWARA method, which is a current multi criteria decision making tool. According to the results of the analysis, it is found that the most important sub-criteria was "Practical Training", while the lowest important criteria was the "Height and weight limits" criterion. With this study, the weights of the military helicopter pilot selection criteria were found for the first time with the Grey SWARA method.

Keywords: military aviation, helicopter pilot, military pilot, pilot selection, personnel selection, grey SWARA, multi criteria decision making.

Introduction

When the development of the aviation industry is examined, it is seen that priority is given to technical factors and aviation safety. In the early years of the helicopter flight, pilot/passenger comfort was of minimal importance compared with the flight safety (Oktay & Sultan, 2015, p. 2876). Then, the technical features and capacity problems of the aircraft came to the fore. For example, control design is critical for safe and performant helicopter operation (Oktay & Sultan, 2013, p. 32). Nevertheless today, aviation studies, which have reached a certain technical capacity, now focus on human-oriented studies.

Aviation activities, where safety and costs come to the fore, require large financial investments. The training of pilots, which is considered an important part of aviation activities, can be counted among aviation activities that require a long time and cost (Griffin & Koonce, 1996). For this reason, determining the pilot selection criteria in the most appropriate way, conducting the selection process correctly and reliably, and graduating the most suitable people as pilots will reduce the problems that will arise from this process.

The aim of the study is to find the weights of the criteria that are effective in the selection of military helicopter pilots with the Grey SWARA method. For this purpose, first, the criteria that are effective in the selection of military helicopter pilots were determined by literature review and interviews with the military personnel working in Armed Forces, and the importance levels of the determined criteria were found using Grey SWARA, one of the current multi criteria decision making methods. Since Grey SWARA is used for the first time in military helicopter pilot selection with this study, it is thought to contribute to the literature.

In the study, first of all, the literature on the use of Grey SWARA and SWARA methods, is reviewed. Then, the grey SWARA method algorithm used in the study is

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explained in the methodology section. The next step is the application part, where the weights of the military helicopter pilot selection criteria are determined. Finally, conclusions gathered from our study and recommendations for future studies are given.

1. Literature review

Identifying the suitable candidates to become a military pilot has been under investigation for a long period of time (Carretta & Ree, 1994; Chidester et al., 1991; Damos, 1996). During World War I, measures of personality characteristics were the main concern of pilot selection process however during and afterwards of World War I1 tests of psychomotor coordination and cognitive skills gain more confidence in pilot selection process (Siem, 1992). These tests used for a long time until 1970's. But since 1970's, studies of multiple aptitudes and psychomotor abilities have been more reliable. In these studies, cognitive ability is generally used as predictor variable (Ree & Carretta, 1996).

Yazgan and Erol (2016), who emphasized that three factors came to the fore within the scope of the pilot selection criteria, defined these factors as intelligence, psychomotor and personality. With the invent of computers, pilot selection process also entered a new era. The use of computers in pilot selection process may have enhanced the predictive power of the psychomotor tests because computers use digital electronic circuitry, rather than analog electromechanical devices. So, the results of tests gathered by computers improved the reliability of the performance measures (Griffin & Koonce, 1996). Furthermore, if the pilot selection process can be supported by personality testing, it can ensure the optimal operational effectiveness and mental health of pilots (King, 2014). For all successful helicopter pilots J. Petrovic and I. Petrovic (2021) identified 27 personality traits. Even though a lot of studies were conducted on personality characteristics of pilot candidates and a good amount of literature is created, these studies couldn't form a single procedure which could be used in military pilot selection process (Siem, 1992).

The methods used in these pilot selection studies also differ. For pilot selection three statistical methodologies – multiple linear regression (MLR), linear discriminant analysis (LDA), and logistic regression (LR) – are commonly used for a long time to create statistical models (Weissmuller & Damos, 2014).

The SWARA method, which is one of the multi-criteria decision-making methods, was introduced by Keršulienė et al. (2010). The SWARA method, Grey SWARA obtained by adapting the grey theory to SWARA, and Fuzzy SWARA obtained by adapting the Fuzzy numbers to SWARA, are used to find the degree of importance of the evaluation criteria. As a result of the literature research, it is seen that SWARA method is applied in many subjects such as supplier selection (Ulutaş, 2021), personnel selection in the aviation industry (Özdağoğlu et al., 2021), machine workbench selection in the manufacturing industry (Aghdaie et al., 2013), evaluation of airports performance (Keleş et al., 2021), evaluation of the service quality offered by airports (Pamucar et al., 2021), evaluation of supply chain management (Dahooie et al., 2020), logistics performance analysis (Ulutaş & Karaköy, 2020), selection of contractors in the construction industry (Çakır, 2017; Cao et al., 2019), performance evaluation of businesses operating in the stock market (Özdağoğlu & Keleş, 2019), selection of establishments in the energy industry (Supçiller & Bayramoğlu, 2020), the evaluation of web pages of companies engaged in e-commerce (Stanujkić et al., 2021). In recent years, the number of studies using Grey SWARA has been increasing.

A list of studies conducted on the use of SWARA, Grey SWARA and Fuzzy SWARA Methods and studies on helicopter pilot selection is given in Table 1.

Table 1. Considered problematic areas and methods (formed by Authors)

Authors	Problem	Methods
SWARA, Fuzzy SWARA and Grey SWARA Method		
Aghdaie et al. (2013)	Selection of optimal machine tool for a manufacturing company.	SWARA and COPRAS-G
Çakır (2017)	Selection the contracting firm, which will construct the new building, by using SWARA-based Grey Relationship Analysis method.	SWARA and Grey Relationship Analysis Method
Özdağoğlu and Keleş (2019)	Performance evaluation of manufacturing companies operating in Borsa Istanbul from the perspective of bankers.	SWARA and Grey Relational Analysis – (GRA)
Cao et al. (2019)	Contractor selection for floating solar panel energy system installation.	Grey SWARA and FUCOM
Dahooie et al. (2020)	Value engineering application for cost reduction in supply chain management at a power plant in Iran.	Grey SWARA and Grey EDAS
Supçiller and Bayramoğlu (2020)	Finding a solution to the wind farm location selection problem of a company operating in the energy sector.	SWARA, I-GRA (Interval grey numbers) and Grey EDAS
Ulutaş and Karaköy (2020)	Analysing of Logistics Performance Index values of countries of transition economies.	Grey SWARA-Grey MOORA
Pamucar et al. (2021)	A case study for evaluating quality of services offered by five main airports located in Spain.	SWARA-G and MARCOS-G

End of Table 1

Authors	Problem	Methods
Stanujkić et al. (2021)	Evaluation from the perspective of first-time visitors to e-commerce sites in Belgrade, Serbia.	Grey SWARA and Grey PIPRECIA
Keleş et al. (2021)	Evaluation of Isparta Süleyman Demirel, Denizli Çardak and Uşak Airports from the perspective of passengers who prefer air transportation.	Fuzzy SWARA, CODAS, ARAS, Fuzzy CODAS, Fuzzy ARAS
Özdağoğlu et al. (2021)	Determining the criteria that airline companies should consider in hiring cabin attendants and choosing the most suitable alternative among cabin attendant alternatives for an airline company.	Fuzzy SWARA and Fuzzy MARCOS
Ulutaş (2021)	Choosing an optimal third-party logistics provider (3PL) for a Turkish textile company producing fabric.	Grey SWARA and Grey CODAS
Helicopter Pilot Selection Studies		
Diamond (1982)	Determining pilot selection criteria for the AH-64 attack helicopter.	Statistical analysis
Mullins (1993)	Determining female combat helicopter pilot selection criteria.	Test, analyse
Bartram (1987)	Development of an automatic test system with hardware and software features for the selection of UK Army Air Force pilot trainees.	Test, analyse, statistical modelling
Ergin (2007)	Determination of hearing loss levels in helicopter pilots and flight technicians.	Measurement-Statistical analysis
Park et al. (2019)	Investigation of the relationship between flight training factors and learning achievement in military helicopter pilot training course in the army.	Measurement-Statistical analysis
Griffin and Koonce (1996)	provides an historical perspective of automated tests for the selection of pilot trainees.	Review of tests for the selection of pilot trainees
King (2014)	Assessment of personality when selecting pilots.	Meta-analytical studies
Carretta and Ree (1994)	Using different types of selection procedures Air Force pilot training candidates and comparing between procedures.	Measurement-Statistical analysis

2. Methodology

Grey system theory developed by Deng (1982). The basic idea in its emergence is to predict the behavior of uncertain systems, which cannot be overcome by stochastic methods (Köse et al., 2013, p. 462). Grey SWARA method integrates grey system theory and multi criteria decision-making methods. The main advantages of Grey SWARA method are as follows.

1. Grey SWARA method can be used for analyzing the uncertain conditions.
2. Evaluation process of the experts is simple. Let the total number of criteria be 10. In this case 9 evaluations will be necessary for Grey SWARA calculation process. For the same problem in case Analytic Hierarchy Process (AHP) methodology is used, expert will make 45 pairwise comparisons.

Grey SWARA method, which is one of the multi-criteria decision-making methods, was used in the study. The steps of the Grey SWARA method are explained below with equations.

2.1. Grey SWARA

Grey SWARA is the adaptation of grey theory (Chandra, 2020) to SWARA method. Grey SWARA process is as follows (Cao et al., 2019).

In the first phase of Grey SWARA method, the experts rank the criteria from the most important criterion to the least important criterion.

j: criterion; $j = 1, 2, 3, \ldots n$
d: decision maker; $d = 1, 2, 3, \ldots D$

$$\begin{cases} j = 1 \Rightarrow \textit{the most important criterion} \\ j = n \Rightarrow \textit{the least important criterion} \end{cases}.$$

Then, the decision makers determine the grey comparative importance values.

$\underline{s}_{jd}$: *lower limit of grey evaluation according to decision maker d criterion j*

$\overline{s}_{jd}$: *upper limit of grey evaluation according to decision maker d criterion j*

After collecting the opinions of the decision makers, the mathematical process of Grey SWARA method starts. The first mathematical operation of Grey SWARA method is to calculate grey comparative coefficients by using Equation (1) and (2).

$\underline{k}_{jd}$: *lower limit of grey comparative coefficient*

$\overline{k}_{jd}$: *upper limit of grey comparative coefficient*

$$\begin{cases} j=1 \Rightarrow \underline{k}_{jd}=1 \\ j>1 \Rightarrow \underline{k}_{jd}=1+\underline{s}_{jd} \end{cases}; \tag{1}$$

$$\begin{cases} j=1 \Rightarrow \overline{k}_{jd}=1 \\ j>1 \Rightarrow \overline{k}_{jd}=1+\overline{s}_{jd} \end{cases}. \tag{2}$$

The next step of Grey SWARA method is to find grey unscaled weights of the criteria with Equations (3) and (4).

$\underline{q}_{jd}$: *lower limit of grey unscaled weight*

$\overline{q}_{jd}$: *upper limit of grey unscaled weight*

$$\begin{cases} j=1 \Rightarrow \underline{q}_{jd}=1 \\ j>1 \Rightarrow \underline{q}_{jd}=\dfrac{\underline{q}_{(j-1)d}}{\overline{k}_{jd}} \end{cases}; \tag{3}$$

$$\begin{cases} j=1 \Rightarrow \overline{q}_{jd}=1 \\ j>1 \Rightarrow \overline{q}_{jd}=\dfrac{\overline{q}_{(j-1)d}}{\underline{k}_{jd}} \end{cases}. \tag{4}$$

Grey scaled weights are found by using Equations (5) and (6).

$\underline{w}_{jd}$: *lower limit of grey scaled weight*

$\overline{w}_{jd}$: *upper limit of grey scaled weight*

$$\underline{w}_{jd}=\frac{\underline{q}_{jd}}{\sum_{j=1}^{n}\overline{q}_{jd}}; \tag{5}$$

$$\overline{w}_{jd}=\frac{\overline{q}_{jd}}{\sum_{j=1}^{n}\underline{q}_{jd}}. \tag{6}$$

Scaled weights are found by using Equation (7).

w_{jd}: *scaled weight of criterion j according to expert d*

$$w_{jd} \quad \frac{\underline{w}_{jd} \quad \overline{w}_{jd}}{\sum_{j\ 1}^{n}\left[\underline{w}_{jd}+\overline{w}_{jd}\right]}. \tag{7}$$

The opinions of the decision makers are integrated by using Equation (8).

w_j: *integrated scaled weight of criterion j*

$$w_j=\frac{\sum_{d=1}^{D} w_{jd}}{D}. \tag{8}$$

2.2. Application

First, military helicopter pilot selection process is identified by reviewing the Military Student Regulations applied in Turkey. The first step in the selection of military helicopter pilots is the identification of pilot candidates. After the standing made according to the academic success of the candidates in the last year of the Military Academy, the determined number of candidates is first subjected to a health examination (Milli Savunma Üniversitesi, 2021). In this part of the selection process candidates' physical conditions are examined. Candidates who pass the health examination successfully are subjected to the Pilot Selection System, in which their psychomotor abilities are measured. Finally, candidates who get a passing grade from the Pilot Selection System are taken to the academic and practical pilot training courses (Ağaşcıoğlu, 2011).

Candidates passing through a basic training process according to the criteria stated below are graduated as helicopter pilots. Afterwards, they are subjected to aircraft type rating training (Utility, Heavy-lift, or Attack), suitable for the helicopter model they will work with.

The pilot selection criterion list can be seen in Table 2.

Table 2. Codes, names and explanations for criteria

Code	Name of the Criteria	Explanation
A	MAIN CRITERIA-1: Health Main Criteria	This is the stage where the physical health status of the pilot candidates is checked. Since flight conditions consist of difficult stages, pilot candidates are expected to be at a level of health that can withstand these difficult conditions (Mullins, 1993).
A1	Height and weight limits	It is requested that the height and weight of the pilot candidate be within the limits set for the aircraft.
A2	Visual limits	In addition to the visual capacity of the pilot candidate, depth perception and colour blindness are determined.
A3	Hearing Limits	The hearing capability of the pilot candidate is measured by audiometry tests.
A4	Performance Limits	The physical performance of the pilot candidate is determined by measuring the heart rhythm during walking and running.
A5	Breathing Test	It is tested whether the pilot candidate has respiratory problems.
A6	Cardio Controls	It is tested whether the pilot candidate has a heart problem.
A7	Flight Physiological Training	The level of adaptation of the pilot candidate to the flight conditions is measured by applying tests such as pressure chamber test and G test (Ree & Carretta, 1996).

End of Table 2

Code	Name of the Criteria	Explanation
B	MAIN CRITERIA-2: Psychomotor Main Criteria	Pilot candidates are placed in control units designed as the flight cabin of the aircraft. Under difficult flight conditions, pilots are expected to be able to make the right decision and to have a good grasp of the general condition of the aircraft and the cautions and warnings it produces (Griffin & Koonce, 1996; Yazgan & Erol, 2016).
B1	Target acquisition:	The pilot candidates' psychomotor activities are controlled by firing missiles at the targets that appear on the cabin screen.
B2	Altitude maintenance:	The candidate's psychomotor activities are controlled by asking the pilot candidates to stay at the same flight level as the targets appearing on the cabin screen.
B3	Maintaining Speed and Heading:	The candidate's psychomotor activities are controlled by asking the pilot candidates to navigate at the same speed and direction as the targets appearing on the cabin screen.
B4	Listening:	Pilot candidates are expected to obey the voice commands and warnings given while following the targets appearing on the cabin screen.
C	MAIN CRITERIA-3: Education and Training Main Criteria	This is the stage where pilot candidates are given academic and practical training. At this stage, the pilot candidates are given academic and practical training on the operation and use of aircraft (Damos, 1996).
C1	Academic Training:	The candidate is subjected to academic training related to flight. The passing grade of the courses is 75. However, he/she must get 100 full marks from the Emergencies Course.
C2	Flight Practical Training:	The candidate receives hands-on training on the ground controls of the aircraft, engine starting, ground taxi, runway controls, take-off, manoeuvring, landing, navigation, and flight failures. Candidates take a solo flight after the first 10 hours of flight training.

Then, to determine the criteria weights, five military pilot instructors who are experts in helicopter piloting and pilot training and have many years of military experience were determined. Each of the experts has a helicopter pilot certificate for at least 15 years and has performed helicopter flights for at least 3000 hours. In addition, the experts have been working as helicopter pilot instructors for at least five years and have taught hundreds of pilot candidates during this period. Two experts have retired from duty in the last year, but three experts are still working as helicopter pilots and trainers.

Finally, these experts are asked to evaluate the criteria's and ranked them from the most important criterion to the least important criterion independently. The evaluations of the experts were interpreted using the Grey SWARA method and the results are given below.

2.3. Analysis of results

Calculation procedure of the first decision maker will be shown step by step. The first decision maker determined the comparative importance values. Grey comparative coefficients of main criteria were calculated by using Equation (1) and (2). Table 3 shows the grey comparative importance values and grey comparative coefficients for main criteria.

Table 3. $\underline{s}_{j1},\overline{s}_{j1},\underline{k}_{j1},\overline{k}_{j1}$, values (main criteria)

N/A	$\underline{s}_{j1}$	$\overline{s}_{j1}$	$\underline{k}_{j1}$	$\overline{k}_{j1}$
B	N/A	N/A	1.0000	1.0000
C	0.0000	0.2000	1.0000	1.2000
A	0.2000	0.4000	1.2000	1.4000

Grey unscaled weights of the main criteria were found with Equations (3) and (4). Grey scaled weights were found by using Equations (5) and (6). Scaled weights were found by using Equation (7). These results can be seen in Table 4.

Table 4. $\underline{q}_{j1},\overline{q}_{j1},\underline{w}_{j1},\overline{w}_{j1},w_j$ values (main criteria)

N/A	$\underline{s}_{j1}$	$\overline{s}_{j1}$	$\underline{k}_{j1}$	$\overline{k}_{j1}$	w_j
B	1.0000	1.0000	0.3529	0.4118	0.3779
C	0.8333	1.0000	0.2941	0.4118	0.3488
A	0.5952	0.8333	0.2101	0.3431	0.2734

As it is seen from data presented in Table 5 the grey comparative importance values and grey comparative coefficients for sub criteria of main criterion A.

Table 5. $\underline{s}_{j1},\overline{s}_{j1},\underline{k}_{j1},\overline{k}_{j1}$, values (sub criteria for A)

N/A	$\underline{s}_{j1}$	$\overline{s}_{j1}$	$\underline{k}_{j1}$	$\overline{k}_{j1}$
A2	N/A	N/A	1.0000	1.0000
A3	0.0000	0.2000	1.0000	1.2000
A6	0.0000	0.2000	1.0000	1.2000
A7	0.2000	0.4000	1.2000	1.4000
A4	0.2000	0.4000	1.2000	1.4000
A5	0.2000	0.4000	1.2000	1.4000
A1	0.4000	0.6000	1.4000	1.6000

Grey unscaled weights of the sub criteria of main criterion A were found with Equations (3) and (4). Grey scaled weights were found by using Equations (5) and (6). Scaled weights were found by using Equation (7). These results can be seen in Table 6.

Table 6. $\underline{q}_{j1}, \overline{q}_{j1}, \underline{w}_{j1}, \overline{w}_{j1}, w_j$ values (sub criteria for A)

N/A	$\underline{s}_{j1}$	$\overline{s}_{j1}$	$\underline{k}_{j1}$	$\overline{k}_{j1}$	w_j
A2	1.0000	1.0000	0.1812	0.2639	0.2077
A3	0.8333	1.0000	0.1510	0.2639	0.1936
A6	0.6944	1.0000	0.1258	0.2639	0.1818
A7	0.4960	0.8333	0.0899	0.2199	0.1445
A4	0.3543	0.6944	0.0642	0.1833	0.1155
A5	0.2531	0.5787	0.0458	0.1527	0.0927
A1	0.1582	0.4134	0.0287	0.1091	0.0643

According to Table 7 data, it can be concluded that the grey comparative importance values and grey comparative coefficients for sub criteria of main criterion B.

Table 7. $\underline{s}_{j1}, \overline{s}_{j1}, \underline{k}_{j1}, \overline{k}_{j1}$, values (sub criteria for B)

N/A	$\underline{s}_{j1}$	$\overline{s}_{j1}$	$\underline{k}_{j1}$	$\overline{k}_{j1}$
B2	N/A	N/A	1.0000	1.0000
B3	0.0000	0.2000	1.0000	1.2000
B4	0.2000	0.4000	1.2000	1.4000
B1	0.6000	0.8000	1.6000	1.8000

Grey unscaled weights of the sub criteria of main criterion B were found with Equations (3) and (4). Grey scaled weights were found by using Equations (5) and (6). Scaled weights were found by using Equation (7). These results can be seen in Table 8.

Table 8. $\underline{q}_{j1}, \overline{q}_{j1}, \underline{w}_{j1}, \overline{w}_{j1}, w_j$ values (sub criteria for B)

N/A	$\underline{s}_{j1}$	$\overline{s}_{j}$	$\underline{k}_{j1}$	$\overline{k}_{j1}$	w_j
B2	1.0000	1.0000	0.2981	0.3624	0.3241
B3	0.8333	1.0000	0.2484	0.3624	0.2997
B4	0.5952	0.8333	0.1775	0.3020	0.2352
B1	0.3307	0.5208	0.0986	0.1888	0.1410

By data shown in Table 9, it is clear that the grey comparative importance values and grey comparative coefficients for sub criteria of main criterion C.

Table 9. $\underline{s}_{j1}, \overline{s}_{j1}, \underline{k}_{j1}, \overline{k}_{j1}$, values (sub criteria for C)

N/A	$\underline{s}_{j1}$	$\overline{s}_{j1}$	$\underline{k}_{j1}$	$\overline{k}_{j1}$
C2	N/A	N/A	1.0000	1.0000
C1	0.2000	0.4000	1.2000	1.4000

Grey unscaled weights of the sub criteria of main criterion C were found with Equations (3) and (4). Grey scaled weights were found by using Equations (5) and (6). Scaled weights were found by using Equation (7). These results can be seen in Table 10.

Table 10. $\underline{q}_{j1}, \overline{q}_{j1}, \underline{w}_{j1}, \overline{w}_{j1}, w_j$ values (sub criteria for C)

N/A	$\underline{s}_{j1}$	$\overline{s}_{j1}$	$\underline{k}_{j1}$	$\overline{k}_{j1}$	w_j
C2	1.0000	1.0000	0.5455	0.5833	0.5631
C1	0.7143	0.8333	0.3896	0.4861	0.4369

This calculation process was repeated for all experts. The opinions of the decision makers are integrated by using Equation 8. The weights and integrated weights can be seen in Table 11.

Table 11. w_{jd}, w_j values

Criterion	w_{j1}	w_{j2}	w_{j3}	w_{j4}	w_{j5}	w_j
A1	0.0176	0.0101	0.0132	0.0236	0.0108	0.0151
A2	0.0568	0.0697	0.0674	0.0765	0.0560	0.0653
A3	0.0529	0.0281	0.0588	0.0425	0.0520	0.0469
A4	0.0316	0.0263	0.0276	0.0341	0.0280	0.0295
A5	0.0253	0.0167	0.0191	0,.0447	0.0179	0.0247
A6	0.0497	0.0209	0.0402	0.0563	0.0223	0.0379
A7	0.0395	0.0415	0.0627	0.0713	0.0410	0.0512
B1	0.0533	0.0688	0.0512	0.0854	0.0483	0.0614
B2	0.1225	0.1127	0.1367	0.0971	0.1134	0.1165
B3	0.1132	0.0878	0.1263	0.1047	0.1048	0.1074
B4	0.0889	0.0468	0.0856	0.0907	0.0710	0.0766
C1	0.1524	0.2056	0.1359	0.1194	0.2081	0.1643
C2	0.1964	0.2650	0.1752	0.1539	0.2262	0.2033

Table 11 was created as a result of the analysis of the opinions of the experts. When Table 11 is generally examined, it is seen that the most weighted item is "C2 Practical Training" (wj:0.2033). It is reasonable that practical training is the point where all other factors come together and put into practice. You can also see the results of academic training, and you can test the health and psychomotor requirement in this section of training. The second most weighted item in the scale is the "C1 Academic Training" (wj:0.1643). Academic training is the part of education process where pilot candidates get the necessary information to fly an aircraft. Pilot candidates should get the academic training to be a good pilot.

When we examine the sub criteria individually:

1. In the health main criteria, it is seen that the most weighted items are "A2 visual" (wj:0.0653) and "A3 hearing" (wj:0.0469). It is anticipated that these criterions got the highest weights because visual and hearing abilities are must for flight and endurance in the flight environment is necessary for flight operations.
2. In the psychomotor main criteria, it is seen that the most weighted items are "B2 maintaining the altitude" (wj:0.1165) and "B3 maintaining the speed

and heading" (wj:0.1074). These criterions got the highest weights because these are the main requirements to have the aircraft fly where the other two criteria in this section are more important for the accomplishment of a possible mission. If the candidates fail at these two criteria, it will be impossible for them to fly the aircraft and accomplish the mission.

3. In the education and training main criteria, it is considered that the practical flight training is more important that the academic training. Because practical training is the place where the candidate can show all his knowledge and capability on action. His health condition can also affect his performance at this stage.

As a result, it is seen that practical performance of pilot candidates are considered as the most important factor. The pilot candidate's practical performance is followed by academic performance. And finally, their visual and hearing limits are considered as the most important factor while determining candidates to fly an aircraft.

Conclusions

Helicopter used for military purposes constitute an important part of national defense due to both their costs and the power factors they have. In addition, helicopters used in the military require large financial investments because they are an effective force in the security, defense, and wartime of a country. The training of pilots who will use military helicopters, which have such strategic importance and cost, takes a long time, and constitutes a large cost item within the military budgets. Therefore, it is of great importance to determine the most appropriate military helicopter pilot selection criteria, to carry out the selection process correctly and reliably, and to select and assign military helicopter pilots. For this reason, selection criteria have been tried to be established by considering many physical, psychological, and psycho-motor factors in the selection of military pilots.

In this context, the aim of the study is to apply the Grey SWARA method to determining the weights of the criteria that are effective in the selection of military helicopter pilots. For this purpose, first, three main criteria and thirteen sub-criteria that are effective in the selection of military helicopter pilots were determined by the review of Military Student Regulations and literature review. In determining the criteria, many factors such as physical, psychological, psycho-motor, health, education, which are effective in the selection of military helicopter pilots, were taken into consideration. After the criteria were determined, five experts were selected among experienced military pilot instructors to score the weights of these criteria. The Grey SWARA method were applied to the scores to find the weights of the evaluation criteria. The application of the Grey SWARA method for the first time on this subject constitutes one of the original aspects of this study.

According to the analysis results, it has been determined that practical training is more important than other criteria. Since practical education is a stage in which the knowledge and skills obtained in other education stages are revealed and put into practice, it has been an expected result to emerge more important than other criteria. In addition to practical training, it has been revealed that academic training is also important in the selection of military pilots. Since the academic training is the place where the pilot candidates receive the basic training to fly the aircraft, it is an anticipated result to be evaluated as having secondary importance.

Within the scope of the findings, it has been determined that practical training is more important than other factors in the selection and training of military pilots. In this context, it would be beneficial to give more importance to practical training and to spend more time in the selection of military pilots in normal periods. In addition, it is considered that practical training can be given importance by ignoring the health and academic training requirements in war-like situations that will require an urgent need for pilots.

Even though our study has significant findings on the selection criteria of military helicopter pilots, in future studies criteria weights can be found with a different multi criteria decision making method or personnel selection criteria can be evaluated for different types of aircraft.

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Author contributions

S. Kurnaz, M. K. Keleş and A. Özdağoğlu conceived the study and were responsible for the design and development of the data analysis. S. Kurnaz, M. K. Keleş and A. Özdağoğlu were responsible for data collection and analysis. M. K. Keleş and A. Özdağoğlu were responsible for data interpretation. S. Kurnaz wrote the first draft of the article.

Disclosure statement

The authors declare that there is no conflict of interest. In this study, there is no need for ethics committee approval because of using open-source databases.

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Notations

Variables and functions

j: criterion; $j = 1, 2, 3, \ldots n$*;*

d: decision maker; $d = 1, 2, 3, \ldots D$*;*

$$\begin{cases} j = 1 \Rightarrow \text{the most important criterion} \\ j = n \Rightarrow \text{the least important criterion} \end{cases};$$

$\underline{s}_{jd}$*: lower limit of grey evaluation according to decision maker d criterion j;*

$\overline{s}_{jd}$*: upper limit of grey evaluation according to decision maker d criterion j;*

$\underline{k}_{jd}$*: lower limit of grey comparative coefficient;*

$\overline{k}_{jd}$*: upper limit of grey comparative coefficient;*

$\underline{q}_{jd}$*: lower limit of grey unscaled weight;*

$\overline{q}_{jd}$*: upper limit of grey unscaled weight;*

$\underline{w}_{jd}$ *: lower limit of grey scaled weight;*

$\overline{w}_{jd}$ *: upper limit of grey scaled weight;*

w_{jd}*: scaled weight of criterion j according to expert d;*

w_j*: integrated scaled weight of criterion j.*

Abbreviations

Fuzzy SWARA – Fuzzy Stepwise Weight Assessment Ratio Analysis;
Grey SWARA – Grey Stepwise Weight Assessment Ratio Analysis;
LDA – Linear Discriminant Analysis;
LR – Logistic Regression;
MLR – Multiple Linear Regression;
SWARA – Stepwise Weight Assessment Ratio Analysis.