

IDENTIFYING FATIGUE OF FLIGHT ATTENDANTS IN SHORT-HAUL OPERATIONS

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Abstract

How much the flight crew can contribute to the flight safety depends on if they can perform their duties properly. Flight crew needs adequate rest before they can carry on their next mission. If they perceive fatigues due to work both mentally and physically, not only that they may not be able to provide appropriate cabin services, but also their awareness of abnormal situations and response ability will be weakened, and this may render potential lethal risks to flight safety. This research is to evaluate cabin crew's fatigue levels before and after flight of certain domestic airlines, and to investigate the subjective perceptions of fatigues of the cabin crews. Then, the differences are analyzed to understand the changes in fatigue perception level before and after flights.

A particular domestic airline was selected to be the research object. In order to measure fatigue level of the cabin crew, University Rene Descartes & Airbus Industrie Fatigue Scale was applied in this research. In addition, this research also addresses to the factors that affect the arousal level of the cabin crew. In this paper, "arousal level before duty", "arousal level after duty" and "arousal level difference between before and after duty" are defined as dependent variables, other possible factors are defined as independent variables, then the cross-analysis are conducted to understand the factors that govern the fatigue level of cabin crew.

Through this research, the results are as follows :

1. Arousal level before duty :

The most significant variable to arousal level before duty is "Sleep status/ adequate rest ". Secondly, "the number of children under eighteen in house", and thirdly, "Sleep status / couldn't get up timely ".

2. Arousal level after duty :

The three most relevant and significant factors of the arousal level after duty are 「 Ever feel tired in duty 」 , 「 Ever involuntarily take naps during turn-around time 」 and 「Traffic time from living site to report-for-duty site 」 .

3. The difference in arousal level between before and after duty:

When taking the difference in arousal level between before and after duty for variable significance analysis, three significant variables can be extracted, which are 「Traffic time from living site to report-for-duty site 」 , 「Average turn-around and cabin operation time of regional flights 」 and 「Ever feel tired in duty 」 .

In this research, correlation analysis is also done on job functions in each phase of flight, and arousal level after duty, along with two significant correlated variables are acquired, which are 「Descending & Taxiing-out / Security Check 」 and 「After flight / Seats organization 」 , in order. The three job functions which most significantly correlated to the difference of arousal level

between before and after duty are 「In-flight/ Duty-free merchandizes and special meal menu」, 「Passengers boarding and taxiing-out/demonstration of the usage of life vests」, and 「In-flight / sales of air boutique goods」, in order.

1. Introduction

How much the flight crew can contribute to the flight safety depends on if they can perform their duties properly. Flight crew needs adequate rest before they can carry on their next mission. If they perceive fatigues due to work both mentally and physically, not only that they may not be able to provide appropriate cabin services, but also their awareness of abnormal situations and response ability will be weakened, and this may render potential lethal risks to flight safety.

Durwood J.Heinrich (2003) deems that fatigue is one of the syndromes that indicate physical stress. Dangers that physical stress may bring up in aviation context are judgment and decision-making abilities damages, reduced awareness of environments and increased response time, as well as the lost of situational awareness, absentmindedness and carelessness. When cabin crew perceives fatigues due to work pressure, their awareness level and response ability to abnormal and emergency situations will be lowered, and thus the flight safety risk rises.

In this research, fatigue level of certain domestic airlines cabin crew before and after duty are measured, then the cabin crew's fatigue level perceived before and after duty are investigated and analyzed to understand fatigue level's variance before and after duty.

In addition, the factors that affect the arousal level of cabin crew are also addressed in this research. "Arousal level before duty", "Arousal level after duty", and "Arousal level difference between before and after duty" are defined as dependent variables, other possible factors which may affect cabin crew's fatigue level are defined as independent variables, then cross-

analysis are conducted to find out significant factors that dominate the fatigue level of cabin crew. This research could be considered as a reference for cabin crew management improvement that has the goal of fatigue alleviation of domestic airlines' cabin crew, and for maintaining flight safety and to perfect cabin services as well.

2. Analysis of Cabin Crew Duty

In arousal research literatures, Yerkes & Dodson (1908) thought that the relationship between arousal and performance is presented as Fig.1. , Appropriate arousal level makes high performance, excessive or insufficient arousal level makes lower performance.

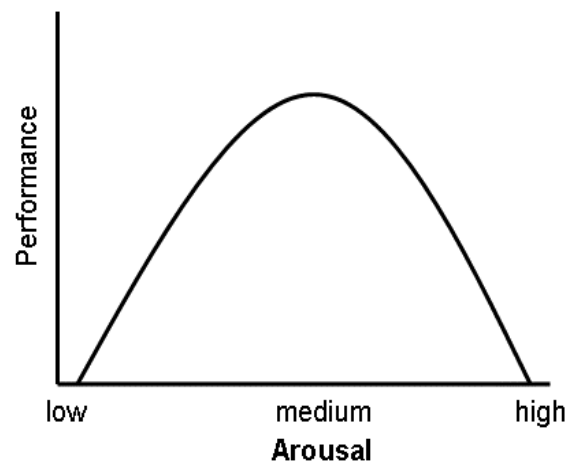


Fig.1. The Relationship Between Arousal and Performance, Source : Yerkes & Dodson (1908)

since that flight safety and service quality are closely correlated in their natures, measuring the fatigue level is the most direct measure for cabin crew fatigue prevention. Cabin crew fatigues were classified as physical fatigue in this research, 暉峻義 (1951) gave physical fatigue a definition of " a collective fatigue problem and a biological phenomenon, as well as an economical and social phenomenon". He emphasized that fatigue is difficult to measure directly due to its complicate nature that usually possessed by organic life forms. Therefore, fatigue problem can only be approached with

indirect but rather objective methods such as investigations of the variances on individual's subjective perceptions, as well as the changes in physiological, functional and effectiveness aspects, followed by interpretations of these data in perspective of collective performance. (I-Fang Mao and Mei-Lien Chen, 1994) The characteristics of cabin crew's work contents can be summarized as physical labor demanding (standing for long time and constantly walking around), highly repetitive yet with low complexity. They are quite different from those of flight crew's work contents, which require high mind-centralization, specialty of aviation knowledge and expertise of instrument operation. Based on above characteristics cabin crew's work fatigue was classified as physical fatigue. To prevent fatigue is not only to maintain cabin crew's arousal level and to enhance flight safety, but is also to maintain cabin crew's work efficiency and service quality. This paper analyzed the nature of cabin crew's work contents in three aspects, which are cabin crew's work contents, characteristics and fatigue factors.

2.1 Cabin crew work contents

Cabin crew's work contents of domestic and regional airlines usually can be identified as following items:

2.1.1 Cabin Checks

Check items after the cabin crew's boarded the airplane are system check, cabin hygienic check, service items check and security check. What's worth to notice is that when switching planes due to dispatch reasons, all four checks have to be done again. Therefore, besides of the quick re-positions, prompt completions of above mentioned cabin checks are also required.

2.1.2 Cabin Services

It includes all service items after passengers boarded, such as delivery of papers/magazines, complimentary food services, duty free goods sales and Audio/Video entertainments introductions.

2.1.3 Special Passenger Handling

There may be various situations encountered after boarding, cabin crews may handle with those situations after consulting the *Civil Aviation Regulations* or *Cabin Crew Operation Manual*, when special situations are encountered, they shall handle with them per relevant regulations.

2.1.4 Abnormal Situations & Emergency Procedures

When performing their tasks during flight, cabin crew may encounter situations such as turbulence, searching for explosives, hijack, crew disabled, cabin depressurization, cabin fire, cabin emergency evacuation and emergency landing, etc., except for emergency procedures prescribed in *Cabin Crew Operation Manual*, these eight emergency situations are also incorporated into and accounted for in daily trainings and tests.

Cabin crew's work contents can be divided into six phases in terms of different stages of dynamic flight process as described below:

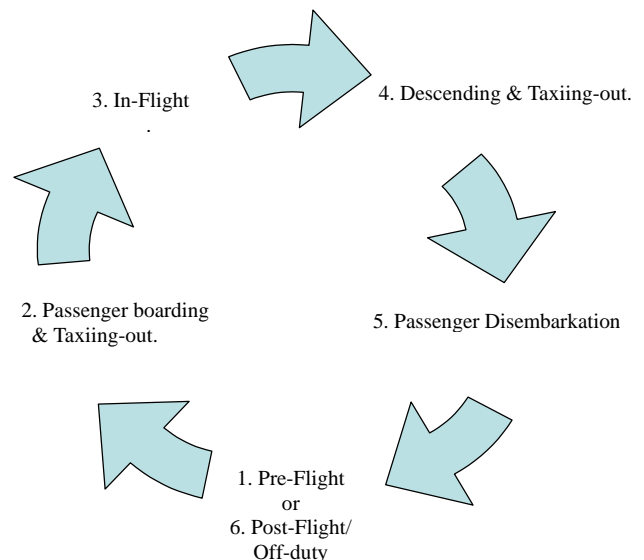


Fig. 2. Flight Stages Correlated to Cabin Crew Duty. (*Far Eastern Air Transport Corp. Cabin Safety Operation Manual, 2005*)

- Pre-Flight
Carry out all cabin checks per designated positions before flight.

- Passenger boarding & Taxing-out
In this phase, besides of welcoming the passengers, handing out papers/magazines and guiding them to their designated seats, cabin crew shall specially note the particular limitations for special passengers and carry-on baggage, locations of dangerous goods and carry-on baggage, and assist passengers to store and secure their baggage.
- In-Flight
Services in-flight include food and beverage cart services, personal towel and papers/magazines delivery, air boutique service and garbage collections.
- Descending & Taxing-out
In this phase, cabin crew end all services and demand passengers to fasten their seat-belts, up-right their seat-backs and stow tray tables, pull down the window shields and lock up the restrooms. After reviewing the cabin and before landing security check is done, cabin crew will report Cabin Ready to captain and have themselves seated for landing.
- Passenger Disembarkation
After connected with the air-bridge and cabin doors are opened, except for greeting farewell to passengers, cabin crews will open all bin doors and check if there's any forgotten baggage or items that not belong to the cabin, then make sure that the restrooms are clear.
- Post-Flight/Off-duty
This phase starts when the crew's finishing their last shift before relieved from whole day's duty, after all the passengers have left, cabin crew will perform cabin security check, caterings check, and shut down the AV system, retrieve the video tapes and organize the cabin crew jump seats, then leave the airplane to another plane or return to dispatch center and prepare for signing-off.

2.2 Characteristics of cabin crew's job functions

Characteristics of cabin crew's job functions could be defined in terms of Physical environment, Working and rest time, Mission dispatch, Flight route types and Emotional labor.

2.2.1 Physical environment characteristics

The daily working environment for cabin crew is aircraft cabin. The characteristics of this environment are the temperature ranged from 20~28°C, low moisture, poor air circulation, noisy and limited resting spaces.

2.2.2 Working and rest time characteristics

As prescribed in *Aircraft Flight Operation Regulation Article 173*, Flight and duty hour of cabin crew should be taken as same as it of pilots, or follow the *Labor Standard Act article 84-1*, and reach a mutual agreed-upon contract between the employer and employees, which should be submitted to local labor authority for approval before implementations. Taking national domestic airlines cabin crews for example, work time is counted with flight schedules. Except for domestic flights, there are also international charters and regular flights. Regardless of the characteristics of the flights, their work time per day may easily exceeds regular eight-hour as it of general labors due to their mission characteristics, and work time may be prolonged further when other unforeseen factors (such as inclement weathers) come into play and delay the flight; Therefore, extended work time is one of the major contributors to cabin crew's flight fatigues. Throughout the work time, cabin crew undertakes extreme stress and mental burden induced by continuous tensions, and this is may be the major cause of physical and mental fatigues. (Jian-Sheng Xu, 1995), (Chen-Chih Yang 2003) Besides of the main mission, the regulation required sing-in/off lead time also contributes extra time demand to actual work time, it's not difficult to conclude that the actual work time has tight connection with cabin crew's fatigues.

2.2.3 Mission Dispatch Characteristics

The number of cabin crews to be dispatched for each flight is prescribed in *Aircraft Flight Operation Regulation Article 170*. For passenger seat number ranged from 20-50, there should be at least one cabin crew on board; for passenger seat number that exceeds 50, there should be two. Follow the same rationale, for every 50 passengers there should be 1 more cabin crew allocated. Besides of the least number of dispatch prescribed by regulations, airlines will also take the route types and peak/off-peak seasonal differences into account, as well as company policies, to be more service-oriented. The limitations of allowable number of take-off/ landing and flight hours are also prescribed in *Aircraft Flight Operation Regulation Article 33* which are as same as those for flight crews. Compared with international routes, there are more takeoff / landing in domestic routes, and each flight's duration time is much shorter than that of international ones, in rather limited time and space, service time and contents are compressed and thus renders fatigue to cabin crews more easily.

2.2.4 Flight Routes Characteristics

For cabin crews, flight route types and flight time can be categorized into the followings:

- Domestic routes:

Defined as the flights between domestic airports in Taiwan, these flights have short flight time and high take-off/landing frequency, and aircrafts can be dispatched and re-allocated with mobility. However, due to short turn-around time (25 minutes, CAA), cabin crews' dining and rest time are also shortened, and it may develop into a cause of work fatigue.

- Regional routes

Regional routes are longer than domestic routes, flight directions are either northward or southward, flight time are ranged from two to six hours. Although there's no crossing between multiple time-zones and thus interferes cabin crew's biological clock, long daily actual work time due to the inclusion of sing-in/off lead time still affects the adequacy of cabin crew's rest time and becomes a major cause of fatigue.

- Trans-oceanic routes

In practical aviation operations, a route that is trans-oceanic with eastward or westward directions or mingled with regional routes which requires flight time over six hours, is called Trans-oceanic route. Due to long flight time and multiple time-zone crossings, chaos of biological clock and jet-lag problems are encountered by the cabin crew, along with long work time and frequent patrolling around in cabin, and frequent body bending for passenger services, are fatigue factors to cabin crew on trans-oceanic flights.

2.2.5 Emotional Labors Characteristics

Emotional control required for work demands cabin crew to maintain incessant smiles and good attitudes, but this kind of professional emotional control isn't easy to be relieved immediately after work. Meanwhile, when cabin crews were imposed with unreasonable requirements from passengers, It's still obliged for them to provide satisfactory services. Long-term emotional suppression along with high emotional labor demands, are the causes of psychological fatigue.

2.3 Cabin crew's work fatigue

This research took *section 3 chapter7 of Occupational health research related technical information collection* as a reference on studying the factors of work fatigue, it can be categorized into Environmental factors, Job function characteristics and Personal factors.

2.3.1 Environmental factors

Hsiao-Wen Chan (2003) mentioned that drastic changes of cabin temperature will make the crew feel uncomfortable, especially when boarding just started in summer season. Low moisture in cabin also induces Xerophthalmia and skin irritations, etc. The noise sources are the engines, but their affection areas are not avoidable when distributing duty areas. In close environments, poor air quality will cause headache, nausea, dizzy, fatigue, organ de-oxidation and other upper respiratory tract diseases. Regarding the rest time, no matter for domestic or regional flights, the whole flight time is deemed as the duty time so there's no

actual rest time at all, and this is also a fatigue factor.

2.3.2 Job functions characteristics

From the introductions of cabin work contents we can know that cabin crew have long work hours and are working in high stress environment at all times, it's the cause of fatigue both physically and psychologically.

2.3.3 Personal factors

陳甦彰〔1981〕's research found that the perception of stress from work vary with personal sexuality, family structure and education level backgrounds. 陳麗芬〔2004〕adapted 陳甦彰's work stress diagnose diagram, and deduced the relationship of work stress and fatigue. She found that personality will affect the perception of work stress, and work stress will induce fatigue. This research took researches mentioned above as foundations, then further explored the personal factors and categorized them into Sexuality, Family structures, Seniority, Personal relationships and Sleep patterns.

3. Questionnaire design and circulations

This research adapted the Fatigue questionnaire designed by Universite Rene Escartes & Airbus Industrie〔Universite Rene Escartes & Airbus Industrie, 1998; Jin-Ru Yen et al., 2004〕to measure the fatigue level of cabin crew both physically and psychologically. Before and after duty subjective fatigue level perception changes of cabin crews of a particular domestic airline are investigated, and the fatigue factors are analyzed. This research took a particular domestic airline's cabin crews in Taipei Songshan International Airport as population, and conducted random samplings. Questionnaires handed out are counted as 120 sets, 117 sets of those are successfully retrieved which renders a retrieving rate of 90%. Key items of the questionnaire are as followings:

- Basic information
- Sleep Pattern
- Sleep status in the previous night of duty
- The process of flight on the day this questionnaire is filled.
- Measurement of cabin crew's subjective fatigue level perception before and after duty.

The questionnaire is consisted of two parts, the first part is for before duty, this part includes cabin crew's personal basic information, sleep patterns and sleep status in the previous night of duty, fill-up time is after crews signing-in and before signing-off. The second part is for after duty, which includes relevant information of the missions that just been completed, and how the cabin crews experienced fatigue and the approaches they resorted to against it, fill-up time is when all missions on that day have all been completed. Meanwhile, to analyze the difference of fatigue level before and after duty, both parts include physical and psychological fatigue level measuring chart.

4. Explorative analysis of cabin crew fatigue

This research adapted factor analysis method on cabin crew fatigue analysis, and categorized fatigue after duty into physical and psychological, and used Paired t-test to do the Variance-analysis and Cross-analysis of potential fatigue factors and cabin crew's arousal level to understand the factors that affect fatigue level.

4.1 Factor analysis of physical and psychological fatigue after duty

This research used Factor-analysis to observe the grouping pattern between variables and found the implicative meanings of them, and used Principle components analysis and the Varimax as a rotated solution, and took eigenvalue greater than 1 as the criterion when choosing the aspects. In the part of physical fatigue after duty, before the analysis there were twenty-four items, after the analysis, three aspects could be extracted and are designated as emotional depression, tired and uncomfortable. In the part of psychological fatigue after duty,

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before the analysis there were two items, after the analysis two aspects could be extracted and are designated as lower performance and emotional depression.

Table 1. Factor Analysis of Physical Fatigue After Duty

Aspect	Variables	Factor pattern value	Eigen-value	Variance value %
Emotional Depression	Getting puzzled	0.824	14.026	58.443
	Irritability	0.820		
	Aggressiveness	0.819		
	Difficulties to evaluate time	0.791		
	Impatience	0.789		
	Depressive state	0.759		
	Headache	0.712		
	Apathy, inertia	0.584		
	Changes of posture	0.569		
	Loss of interest and motivation	0.557		
Frequent desire to drink/eat	0.499			
Tired	Drowsiness	0.810	1.850	7.709 (66.152)
	Growing and irresistible need to sleep	0.768		
	Efforts to maintain arousal	0.692		
	Fixed stare	0.672		
	Awing, falling eyelids	0.628		
	Bad look, paleness	0.623		
	Decrease of verbal communication	0.577		
	Voluntary closing of eyes' during 5 minutes	0.493		

Aspect	Variables	Factor pattern value	Eigen-value	Variance value %
Uncomfortable	Smarting eyes, eye irritation	0.788	1.064	4.432 (70.584)
	Backache, leg pain, limb stretching	0.724		
	Shortening of the field of view	0.657		
	General feeling of getting tired	0.616		
	Neck pain	0.589		

Table 2. Analysis of Psychological Fatigue Factor After Duty

Aspect	Variables	Factor pattern value	Eigen-value	Variance value %
Lower performance	Lack of precision, or rigor during work	0.847	14.267	64.851 (64.851)
	Slips, lapses or minor errors	0.800		
	Error in manipulating controls	0.798		
	Lack of coherence in reasoning	0.792		
	Difficulty to make decision	0.781		
	Substantial efforts to maintain attention	0.728		
	Difficulty in reading and writing	0.718		
	Lack of well known actions and adapted reflexes	0.717		

Aspect	Variables	Factor pattern value	Eigen-value	Variance value %
Lower performance (cont'd)	Slow understanding	0.70	14.267	64.851 (64.851)
	Bad coordination of actions and movements	0.665		
	Tendency to delay decision-making	0.649		
	Difficulty in oral expression	0.626		
	Slow actions and movements	0.624		
	Substantial efforts to maintain attention	0.615		
	Difficulty to speak a foreign language	0.592		
	Easy distractibility	0.590		
Emotional depression.	Desire to get rid of duties	0.799	1.073	1.073 (69.730)
	Lack of anticipation	0.746		
	Focus on one kind of task	0.729		
	Redundancy of some actions	0.639		
	Lack of availability	0.622		
	Little tolerance to changes during flight	0.561		

differences physically are 「Smarting eyes, eye irritation」, 「Shortening of the field of view」, 「General feeling of getting tired」, 「Getting puzzled」, 「Changes of posture」. In all, 「Smarting eyes, eye irritation」 is the most significant item in difference of physical fatigue before and after duty.

Psychologically, items with significant difference between before and after duty are 「Desire to get rid of duties」, 「Lack of availability」 and 「Substantial efforts to maintain attention」 are most significant, and the most prominent one is 「Desire to get rid of duties」, results are presented in Table 4.

Table 3. Analysis of the Physical Fatigue Factor Difference Between Before and After Duty

Physical fatigue item	Mean value before duty	Mean value after duty	Mean value difference before/after duty	P value
Smarting eyes, eye irritation	1.09	1.58	0.49	0.000
Shortening of the field of view	0.89	1.20	0.31	0.004
Backache, leg pain, limb stretching	1.63	1.77	0.14	0.224
Yawing, falling eyelids	1.60	1.69	0.09	0.408
Bad look, paleness	1.29	1.41	0.12	0.331
Headache	0.83	0.97	0.14	0.141
Loss of interest and motivation	1.28	1.24	-0.04	0.704
Depressive state	0.93	0.80	-0.13	0.191
Irritability	1.00	0.89	-0.11	0.272
Fixed stare	0.99	0.93	-0.06	0.555
Growing and irresistible need to sleep	1.49	1.61	0.12	0.338
efforts to maintain arousal	0.84	0.95	0.11	0.298
Frequent desire to drink/eat	1.36	1.26	-0.10	0.357
Getting	0.87	0.69	-0.18	0.031

4.2 Fatigue level difference between before and after duty

Paired-t test is used to examine the fatigue level of before and after duty, items with significant

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Physical fatigue item	Mean value before duty	Mean value after duty	Mean value difference before/after duty	P value
puzzled				
Decrease of verbal communication	1.01	0.94	-0.07	0.542
Changes of posture	1.28	0.90	-0.38	0.000
Drowsiness	1.21	1.13	-0.08	0.504
Voluntary closing of eyes' during 5 minutes	0.84	0.79	-0.05	0.573
Apathy, inertia	1.00	0.95	-0.05	0.617
Neck pain	1.44	1.34	-0.10	0.275
Impatience	1.01	0.90	-0.11	0.231
Difficulties to evaluate time	0.72	0.69	-0.03	0.691
Aggressiveness	0.42	0.41	-0.01	0.824

Table 4. Analysis of the Psychological fatigue factor difference between before and after duty

Psychological fatigue item	Mean value before duty	Mean value after duty	Mean value difference before/after duty	P value
Redundancy of some actions	0.82	0.84	0.02	0.868
Desire to get rid of duties	1.70	2.04	0.34	0.003
Lack of anticipation	1.07	1.01	-0.06	0.579
Lack of availability	0.77	0.95	0.18	0.049
Lack of well known actions and adapted reflexes	0.83	1.01	0.18	0.090
Difficulty to make decision	0.80	0.67	-0.13	0.155
Lack of coherence in reasoning	0.71	0.73	0.02	0.855
Slips, lapses or minor errors	0.83	0.75	-0.08	0.343

Psychological fatigue item	Mean value before duty	Mean value after duty	Mean value difference before/after duty	P value
Lack of precision, or rigor during work	0.63	0.75	0.12	0.169
Little mistakes (calculation, interpretation)	0.73	0.82	0.09	0.379
Slow actions and movements	0.77	0.80	0.03	0.793
Tendency to delay decision-making	0.73	0.83	0.10	0.250
Bad coordination of actions and movements	0.63	0.77	0.14	0.106
Difficulty in oral expression	0.63	0.60	0.03	0.749
Difficulty in reading and writing	0.47	0.55	0.08	0.363
Slow understanding	0.73	0.86	0.13	0.128
Difficulty to speak a foreign language	0.78	0.86	0.08	0.294
Substantial efforts to maintain attention	0.71	0.89	0.18	0.041
Easy distractibility	0.94	1.05	0.11	0.223

4.3 Cross analysis on factors of cabin crew's arousal level

This section discusses the factors that affect the arousal level of cabin crew, taking 「arousal level before duty」 、 「arousal level after duty」 and 「the difference of arousal level between before and after duty」 as independent variables, other possible factors as dependent variables, then cross-analysis were conducted to understand the affection levels of those factors, the factors are presented in Table 5.

Then the cross-analysis of work contents and arousal level between before and after duty was conducted to realize the relationship between duty contents and arousal level after duty. Except for using the fatigue level measurement chart to evaluate physical and psychological fatigue level, the before/after duty arousal level measurement chart that has a scale from 1-19 was also used to evaluate the arousal level of cabin crew.

Table 5. Independent Factors of Fatigue Factor Cross-analysis

Question	Variables	Question	Variables
Interviewee's basic information	Sexuality	Sleep status in the previous night of duty	Average time for falling into sleep after going to bed
	Age		
	Marital Status		How long before you get up from bed after waked up
	Number of children under 18 in house		How many times of wake-ups during sleep
	Number of children above 18 in house		If ever waked up at the night, how long before falling back to sleep in average
	Years of service as a cabin crew		Nap time after got up today
	Years of service in current company		Sleep status / Hard to fall into sleep

Question	Variables	Question	Variables
	Position		Sleep status / Couldn't get up timely
Interviewee's basic information (Cont'd)	Average duty hours per month	Sleep status in the previous night of duty (Cont'd)	Sleep status / Slept well
	Traffic time from living site to report-for-duty site		Sleep status / Adequate rest
Today's mission process	Hours of standby before duty	Sleep pattern at home	Usual time for falling into sleep
	Total number of flights carried-out today		
	Number of domestic flights carried-out today		Average time before falling into sleep after going to bed
	Average turn-around and cabin operation time of domestic flights		Average number of wake-ups during the night today
	Number of regional flights carried-out		If ever waked up at the night, how long in average before falling back to sleep
	Average turn-around and cabin operation time of regional flights		Average time of sleep every night
	Average number of passengers today		

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Question	Variables	Question	Variables
	Number of flights that delay for takeoff over 15 minutes today		Is it hard to sleep after going to bed
Today's mission process (cont'd)	Is there any provisional dispatch today?	Sleep pattern at home (Cont'd)	Generally, how do you rate your sleep status in all?
	Number of time that air bridge is unavailable for boarding/disembarking	Fatigue and flight conditions	Ever feel tired in duty
	Was there rainy weather encountered when boarding/disembarking		Ever taking nap involuntarily in turn-around time
	Cabin environment / Noise		
	Cabin environment /High temperature		
	Cabin environment / Low temperature		
	Cabin environment /Too dry		
	Cabin environment /Too moist		
	Cabin environment /Poor air quality		
	Cabin environment /inadequate resting spaces		

The questionnaire of cabin crew arousal level before and after duty uses a 10-degree scale for arousal strength, and the degree from 1 to 10 represents low to high arousal strength. However, under the restriction of scarce of samples, we decided to simplify the scale into two groups, items that scaled from 1 to 5 degree are categorized as Arousal; items that scaled from 6 to 10 degree are categorized as Highly Arousal. Using this two-group method not only helped to reduce the degree of freedom, but also made the analysis more exact. In addition, this paper used Pearson's Product-moment coefficient of correlation analysis to investigate the significance of correlation between continuous variables and the level of fatigue.

4.3.1 Cross-analysis on Fatigue factors and Arousal level before duty

After cross-analyzed 「Cabin crew's arousal level before duty」 with 「Interviewee's basic information」, 「Sleep status at the night before duty」, 「Today's mission process」, 「Sleep pattern at home」 and 「Fatigue and flight conditions」, results show that 「Arousal level before duty」 is significantly correlated to eleven variables, and 「Sleep status / adequate rest」 is most prominent, results are presented in table 6.

Table 6. Significant Variables That Affect Cabin Crew's Arousal Level Before Duty

Independent variables	Significant variables	P value
Arousal level before duty	Number of children under 18 in house	0.004
	Years of service as a cabin crew	0.019
	Sleep status / Couldn't get up timely	0.009
	Sleep status / Slept well	0.026
	Sleep status / Adequate rest	0.002

The analysis methods used in this research are Chi-square tests and Correlation analysis. Chi-square test was used to investigate whether the relationship between dependent and independent variables in Categorical variables is significant or not. When using Chi-square tests, every expected cell could not be less than 5.

This paper takes the cells merge solution and in order to match up the purpose of research, this paper adjusts the variables and combines some cells. Besides, if the cell expected value in 2 multiplied contingency table is less than 5, then using "Fisher's exact probability test" to analysis the factors that affect fatigue level.

4.3.2 *Cross-analysis on Fatigue factors and Arousal level after duty*

After cross-analyzed potential fatigue factors of 「Cabin crew’s arousal level after duty」, six significant variables are obtained, among them, 「Ever feel tired in duty」 is most prominent, results are presented in Table 7.

Table 7. Significant Variables That Affect Cabin Crew’s Arousal Level After Duty

Independent variables	Significant variables	P value
Arousal level after duty	Age	0.015
	Traffic time from living site to report-for-duty site	0.014
	Average number of passengers today	0.071
	Number of times that the air bridge is not available when passengers board and disembark	0.077
	Ever feel tired in duty	0.000
	Ever involuntarily take naps during turn-around time	0.001

4.3.3 *Cross-analysis fatigue factors and the difference of arousal level between before and after duty.*

The results show that 「The difference of arousal level between before and after duty」 is significantly correlated to three variables, especially, 「Ever feel tired in duty」 is most prominent and results are presented in Table 8.

Table 8. Significant Variables That Affect Cabin Crew’s Arousal Level Difference Between Before And After Duty

Independent variables	Significant variables	P value
The difference of arousal level before and after duty	Traffic time from living site to report-for-duty site	0.010
	Average turn-around and cabin operation time of regional flights	0.016
	Ever feel tired in duty	0.001

Since the arousal level after duty concerns the working performance, in this research the arousal level after duty was taken as an index item of fatigue, the lower the arousal level after duty is, the higher the fatigue level is, they are directly correlated. Cabin crew’s work contents can be further investigated by categorizing them into several phases, this research adapted correlation-analysis to investigate the relationships between the job function variables and the difference of arousal level between before and after duty. The results of analysis show that there are two significant correlated work items which are 「Descending & Taxiing-out / Security Check」 and 「After flight / Seats organization」

Table 9. Significant Job Functions Variables That Affect Cabin Crew’s Arousal Level After Duty

Independent variables	Significant variables	P value
Arousal level after duty	Descending & Taxiing-out / Security Check	0.00
	After flight / Seats organization	0.03

The job functions most significantly correlated to the difference of arousal level between before and after duty in order are 「In-flight/ Duty-free merchandizes and special meal menu」, 「Passenger boarding and taxiing-

out/demonstration of the usage of life vests」 and 「In-flight/ sales of air boutique goods」, results are presented in Table 10.

Table 10. Significant Job Function Variables That Affect Cabin Crew’s Arousal Level

Independent variables	Significant variables	P value
Arousal level difference before and after duty	In-flight/ Duty-free merchandizes and special meal menu	0.010
	Passenger boarding and taxiing-out/demonstration of the usage of life vests	0.014
	In-flight/ sales of air boutique goods	0.016

5. Conclusions

In this research, Subjective measure list is used to evaluate before and after duty fatigue level of cabin crew in a particular domestic airlines, measured variables are analyzed and the difference of fatigue level between before and after duty is compared. Having recognized the fact that fatigue causes the drop of alertness level, this research focuses on before and after duty fatigue level and the difference between them to analyze and find what variables are significantly correlated, the results are as followings:

- Arousal level before duty:
The most significant correlated variable to arousal level before duty is 「Sleep status / Adequate rest」, followed by 「Number of children under 18 in house」 and 「Sleep status / Couldn’t get up timely」.
- Arousal level after duty:
The three most significant relevant variables of arousal level after duty are 「Ever feel tired in duty」, 「Ever involuntarily take naps during turn-around time」 and 「Traffic time from living site to report-for-duty site」.

- The difference in arousal level between before and after duty:
When taking the difference in arousal level between before and after duty for variable significance analysis, three significant variables can be extracted which are 「Traffic time from living site to report-for-duty site」, 「Average turn-around and cabin operation time of regional flights」 and 「Ever feel tired in duty」.

In this research, correlation analysis was also done on job functions in each phase of flight and arousal level after duty. Two significant correlated variables are obtained, which are 「Descending & Taxiing-out / Security Check」 and 「After flight / Seats organization」 in order.

The three job functions which most significantly correlated to the difference of arousal level between before and after duty in order are 「In-flight/ Duty-free merchandizes and special meal menu」, 「Passenger boarding and taxiing-out/demonstration of the usage of life vests」 and 「In-flight/ sales of air boutique goods」.

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