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Original Article

Immediate and Sustained Effects of Balance Stabilization by the Prone Abdominal Drawing-in Maneuver

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Abstract: [Purpose] The abdominal drawing-in maneuver (ADIM) is effective in activating the transversus abdominal muscle and stabilizing balance. However, the sustained effect of the ADIM in the prone position (P-ADIM) on balancing ability has not been elucidated. This study examined the sustained effect of P-ADIM on static and dynamic balance. [Subjects and Methods] The participants were 15 healthy non-athlete adult men. They were randomized into the control and P-ADIM groups and subjected to a randomized crossover study. The center of gravity sway in the two-leg and one-leg standing positions and the distance in the functional reach test (FRT) were measured immediately, then at 15 min, and at 30 min after the intervention. [Results] In the P-ADIM group, decrease in the total trajectory length and the rectangular area was sustained for 30 min; whereas, the outer peripheral area decreased immediately after the intervention. An increase in the FRT distance was sustained until 15 min. Meanwhile, no significant differences were noted in the one-leg standing position. [Conclusion] The results suggested that the P-ADIM may be effective in stabilizing static and dynamic balance in both immediate and sustained ways. However, its effect on dynamic balance may disappear faster than its effect on static balance.

Keywords: Abdominal drawing-in maneuver, Transversus abdominal muscle, Sustained effect

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I. INTRODUCTION

The abdominal drawing-in maneuver (ADIM) is performed in diverse stances, including prone [1], seated [2], and standing positions [3], and during various exercises, including walking and stair climbing [4]. ADIM helps specifically contract the transversus abdominal muscle (TrA) [5], which is one of the deep abdominal muscles. Accordingly, it is recognized to be effective in treating chronic lumbago [6, 7]. When males and females with core instability performed ADIM in the prone position (P-ADIM), the TrA thickened [8]. Moreover, a study revealed that ADIM in the standing position helped healthy men and women activate the TrA and stabilize the spine [9].

Kadri et al. [10] had male and female participants of varying ages perform ADIM in either the semi-tandem or one-leg standing position. They reported that ADIM was not effective as no changes in the sway were observed in the center of foot pressure. Meanwhile, another report stated that ADIM helped obese participants with lumbar vertebral instability increase the supportive ability of the lumbar vertebrae by strengthening the TrA, which resulted in improved balancing ability [11]. In general, balancing ability is correlated with trunk muscle strength and spinal alignment [12, 13]. Therefore, P-ADIM may affect the balancing ability of healthy individuals.

However, despite these findings, the immediate and sustained effects of P-ADIM on static and dynamic

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balance have not been elucidated. Clarifying the efficacy of P-ADIM will be beneficial in developing exercise programs for preventing lumbago and falls and improving athletic performance, as well as elucidating their mechanisms.

In this study, we had healthy non-athletic adult men perform P-ADIM to clarify its immediate and sustained effects on static and dynamic balancing ability on posture stabilization.

II. PARTICIPANTS AND METHODS

1. Participants

The participants were 15 healthy non-athlete adult men (Table 1). They were randomized into the control (CON) and P-ADIM groups and subjected to a randomized crossover study.

This study was conducted in accordance with the Declaration of Helsinki, and the content of the study was explained to the participants, whose consent was then obtained. Before implementation, the study was approved by the Ethics Committee for Human Experiments of the Nittazuka Medical Welfare Center (Approval no. 2019-60).

Table 1. Physical characteristics of participants

Age (years)	21.3 ± 0.9
Gender, Male (n)	15
Height (cm)	172.2 ± 5.5
Weight (kg)	61.7 ± 10.4
BMI (kg/m^2)	20.1 ± 2.4

All values are mean ± standard deviation.

BMI: body mass index.

2. Methods

The participants in the CON group were asked to maintain the prone position on a bed for 3 min and did not perform P-ADIM.

The P-ADIM group performed two sets of abdominal drawing-in for 10 seconds and rest for 3 min in the prone position. In addition, the interval between sets was set to 1 min. In each group, an interval of at least 2 days was placed between the days of experiment to prevent a carryover effect.

The ADIM was performed as per the method reported by Nam et al. [8], using a cuff of a mercury sphygmomanometer as a pressure feedback device. A pressure pad was placed so that the center of the pad was on the navel area and the distal edges were on the line connecting the right and left anterior superior iliac spines.

Each participant performed the ADIM while ensuring that the measurement of the pressure pad (which was pressurized to 70 mmHg) indicated 4–10 mmHg. They were verbally instructed to “draw in their abdomen without moving the spinal column and pelvis” and “not to stop breathing while performing the ADIM.”

For static balancing ability, the total trajectory length, the rectangular area, and the outer periphery area were measured using a stabilometer (BALANCECORDER BW-6000, ANIMA Inc. Tokyo) while the participants stared at an object 2 m ahead and assumed either the standing or one-leg standing position barefoot for 30 sec. They were verbally instructed to “stand as steadily as possible.”

For dynamic balancing ability, the participants stood barefoot on the stabilometer and performed a functional reach test (FRT) [14], and the mean central deviation of the sway in 10 sec was measured. Dynamic movement ability was calculated by subtracting the deviation level in the static standing position from the deviation level during forward movement.

To analyze the immediate and sustained effects in the P-ADIM and CON groups, both static and dynamic balancing abilities were measured just before the intervention, and immediately, 15 min, and 30 min after starting the ADIM.

In both CON and P-ADIM groups, the actual measurements of the total trajectory length, rectangular area, and outer periphery area were compared before and after the intervention. In both groups, the values

at 0 min, 15 min, and 30 min were comparatively analyzed for the presence or absence of effect based on the increase–decrease rate normalized by the following equation.

Increase–decrease rate (%) = (t min value after intervention/value before intervention) × 100
Where, t min = 0 min, 15 min, or 30 min

3. Statistical analysis

For statistical analysis, Statcel4, an add-in software in Excel (OMS Inc., Tokyo), was used to compare effects before and after the intervention. The effect of P-AMID training on standing balance were assessed using a two-way repeated measures analysis of variance (ANOVA). When the interaction was not significant and there was a difference in inter-individual variability, after testing normality, the each time point between the CON and P-ADIM groups were assessed using at a paired t-test or Wilcoxon signed-rank test [15, 16]. The statistical significance level was set at $P \leq 0.05$.

III. RESULTS

The two-way repeated ANOVA were a statistical difference between CON and P-ADIM (total trajectory length: $F_{(1, 56)} = 5.346$, $p < 0.05$, rectangular area: $F_{(1, 56)} = 5.009$, $p < 0.05$, outer periphery: $F_{(1, 56)} = 6.624$, $p < 0.05$, FRT: $F_{(1, 56)} = 5.393$, $p < 0.05$). No interaction was detected between the groups and time ($F_{(2, 56)} = 0.181$, $p = 0.834$, $F_{(2, 56)} = 0.028$, $p = 0.972$, $F_{(2, 56)} = 1.421$, $p = 0.249$, $F_{(2, 56)} = 0.752$, $p = 0.475$, respectively).

The total trajectory length, rectangular area, outer periphery area, and FRT distance measured in the standing and one-leg standing positions did not differ significantly between the CON and P-ADIM groups before the intervention. The purpose of this study was to focus on the sustained effects after the intervention, and the rate of increase or decrease at each time point was calculated using the preintervention as 100%.

The comparison results for each time point are shown in Table 2.

Compared to before intervention, the total trajectory length in the standing position decreased by 0.1% at 0 min, 2.1% at 15 min, and 3.4% at 30 min in the CON group, and decreased by 11.5%, 14.7%, and 13.1% in the P-ADIM group. Compared to before intervention, the rectangular area in standing position increased by 26.2% at 0 min, 12.5% at 15 min, and 15.9% at 30 min in the CON group, but decreased by 8.6%, 19.9%, and 14.6% in the P-ADIM group.

The increase–decrease rates showed that the total trajectory length and the rectangular area measured in the standing position both significantly decreased at 0 min, 15 min, and 30 min in the P-ADIM group compared to those in the CON group.

Compared to before intervention, the outer periphery area in standing position increased by 41.0% at 0 min, 10.5% at 15 min, and 19.8% at 30 min in the CON group, but decreased by 12.2%, 14.3%, and 10.5% in the P-ADIM group.

The outer periphery area in the standing position decreased significantly at 0 min in the P-ADIM group compared to that in the CON group; whereas, no significant differences were noted at 15 min and 30 min.

Compared to before intervention, the FRT in standing position increased by 4.9% at 0 min, 3.1% at 15 min, and 6.4% at 30 min in the CON group, and increased by 25.1%, 18.9%, and 18.7% in the P-ADIM group.

The FRT distance significantly increased at 0 min and 15 min in the P-ADIM group compared with the CON group; however, no significant differences were noted at 30 min.

The decrease rates of the total trajectory length, rectangular area, and outer periphery area in the one-leg standing position were not significantly different at 0 min, 15 min, and 30 min between the CON and P-ADIM groups.

Table 2. Comparison between two groups for each factors

Groups	Measurement	Change ratio of data	Pre-intervention	0 min	15 min	30 min
CON	Double-leg standing	Total trace length (%)	—	99.9 ± 14.9	97.9 ± 15.6	96.6 ± 15.8
		Rectangular area (%)	—	126.2 ± 48.9	112.5 ± 44.8	115.9 ± 57.5
		Outer circumference area (%)	—	141.0 ± 60.0	110.5 ± 46.5	119.8 ± 66.0
P-ADIM	Double-leg standing	Total trace length (%)	NS	88.5 ± 13.2*	85.3 ± 16.5*	86.9 ± 13.0*
		Rectangular area (%)	NS	91.4 ± 59.6*	80.1 ± 36.3*	85.4 ± 28.0*
		Outer circumference area (%)	NS	87.8 ± 32.5*	85.7 ± 15.3	89.5 ± 36.5
CON	Single-leg standing	Total trace length (%)	—	100.3 ± 13.4	98.4 ± 13.7	96.1 ± 16.2
		Rectangular area (%)	—	99.9 ± 39.1	99.3 ± 25.8	97.3 ± 27.4
		Outer circumference area (%)	—	100.3 ± 28.2	95.9 ± 21.0	100.6 ± 20.9
P-ADIM	Single-leg standing	Total trace length (%)	NS	98.3 ± 10.4	95.4 ± 14.1	92.4 ± 16.9
		Rectangular area (%)	NS	94.8 ± 26.9	101.2 ± 44.5	111.5 ± 43.2
		Outer circumference area (%)	NS	92.6 ± 34.9	97.0 ± 37.5	106.9 ± 36.9
CON	FRT	Distance (%)	—	104.9 ± 17.4	103.1 ± 15.1	106.4 ± 24.8
P-ADIM	FRT	Distance (%)	NS	125.1 ± 23.1*	118.9 ± 23.1*	118.7 ± 19.9

Values are mean ± standard deviation. P-ADIM: Prone Abdominal Drawing-in Maneuver, FRT: functional reach test.

*Significantly different ($p \leq 0.05$). *p ≥ CON vs P-ADIM. NS: No significant difference.

IV. DISCUSSION

In this study, the total trajectory length, rectangular area, and outer periphery area decreased immediately after the P-ADIM intervention and the FRT distance, on the other hand, increased. These results indicate that P-ADIM is immediately effective in stabilizing static and dynamic balance.

Meanwhile, decrease in the total trajectory length and the rectangular area in the standing position persisted until 30 min after the P-ADIM intervention. However, a decrease in the outer periphery area at 15 min was not significantly different from that in the CON group, and an increase in the FRT distance continued until 15 min.

These results suggest that although the sustained effect of P-ADIM may continue for >30 min for static balancing ability, it may persist until 15 min for dynamic balancing ability. Therefore, the effect of P-ADIM may disappear faster for dynamic balancing ability than for static balancing ability.

Magnetic resonance imaging results demonstrated that ADIM increases the stability of the lumbar vertebrae and pelvis by thickening the TrA [17]. The increase in static and dynamic balancing abilities in this study may be attributed to the increased stability in the lumbar vertebrae and pelvis due to TrA activity.

In this study, P-ADIM exhibited no effect on one-leg standing in terms of the total trajectory length, rectangular area, and outer periphery area. In controlling the posture in the one-leg standing position, the flexor and extensor muscles in the hip joints and the plantar flexor and dorsiflexor muscles in the ankle joints are involved [18]. A report stated that the posture in the static one-leg standing position is normally regulated by the ankle strategy [19]. It has also been demonstrated that proximal muscles are engaged to control the posture when a participant is standing on one leg with eyes closed or when the level of difficulty of a challenge is increased [20]. As a result, the reason why P-ADIM showed no effect on one-leg standing may have been that the ankle strategy is closely associated with controlling the posture in this position than the trunk.

P-ADIM can be trained while receiving abdominal pressure feedback using a sphygmomanometer [21]. In addition, P-ADIM enables muscle strength training of the gluteus maximus and the medial hamstrings

with low activity of the erector spinae for patients with low back pain [22]. There are many methods of low back pain training [23], and P-ADIM will be useful as one of the training methods that can be performed in the prone position.

Finally, it should be noted that the results of this study were obtained from healthy non-athlete male participants and that the sample size and the standard deviations of the participants' age and BMI were small.

Consequently, these results may lack external validity for small children, elderly people, females, athletes, and patients with trunk instability. In future research, the characteristics of the effect of P-ADIM need to be clarified for different age groups, genders, and exercise habits.

FUNDING AND CONFLICT OF INTEREST

No funding was provided for this study. The author has declared that no competing interests exist.

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Report

Relationships among Entrance Examination Score, Academic Performance, and Outcome
(graduation without repeating/graduation with repeating/dropping out)

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Abstract: [Purpose] To clarify the relationships among students' entrance examination score, academic performance (GPA), and outcome (graduation without repeating/graduation with repeating/dropping out). [Participants and Methods] Students in the Department of Occupational Therapy, Faculty of Rehabilitation, Kobe Gakuin University, were divided into graduation without repeating, graduation with repeating, and dropout groups to compare the type of their entrance examination and GPA for required subjects.[Results] There were no significant differences in the type of entrance examination among the three groups, but the dropout group's GPA for required subjects was lower than the graduation without repeating group's GPA for required subjects. [Conclusion] Academic performance was correlated with the outcome more strongly than the type of entrance examination. GPA for required subjects after entrance was shown to be useful to predict student outcome.

Keywords: GPA, ROC analysis, dropping out

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I. INTRODUCTION

More than 10 years have passed since the Faculty of Rehabilitation was founded at Kobe Gakuin University (study university), and the number of graduates from the Department of Occupational Therapy comprising the faculty exceeded 400 by March 2022. Students admitted to this department become qualified to take the national occupational therapist certification examination by obtaining a required number of units from the categories of common education subjects and specialized education subjects. With aging, the expansion of target diseases, and a more diverse occupational field, covering facilities and community-based care settings, in addition to hospitals, the demand for occupational therapists is increasing.

The Department of Occupational Therapy of the study university aims to have its students, ideally most of them, pass the national occupational therapist certification examination after graduation, and obtain an occupational therapist license, but in reality, 20-30% of students drop out or change faculty. On the other hand, the Ministry of Health, Labour, and Welfare examined physical/occupational therapist school students' outcomes after entrance, and reported that the rate of graduation without repeating the same year was 72.4%, and that of dropping out was 12.5%[1)]. Previous studies involving students in the Department of Physical Therapy of the study university[2, 3)] revealed that the grade point average (GPA) of students who drop out or change faculty, calculated from their grades for relevant specialized required subjects soon after entrance into university, was significantly lower. However, the relationship between the

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academic performance and outcome (graduation without repeating, graduation with repeating/dropping out) of students in the Department of Occupational Therapy has yet to be clarified.

It is also important for occupational therapist schools to identify students at risk of dropping out as soon as possible after entrance into the school, and provide appropriate guidance for them.

Therefore, the present study examined students admitted to the Department of Occupational Therapy of the study university, dividing them into those who dropped out and those who graduated with/without repeating the same year to compare their pre-admission performance and GPA calculated from their grades for specialized required subjects (GPA for required subjects) as well as to clarify the identifiability of students at risk of dropping out soon after entrance using ROC curves.

II. PARTICIPANTS AND METHODS

Among a total of 172 students admitted to the Department of Occupational Therapy of the study university in 2015, 2016, 2017, and 2018 using the same entrance examination system and education curriculum, we included 166, excluding 6 who were still in school when conducting this study. There were 66 males and 100 females. Their outcomes were as follows: graduating without repeating the same year: 106; repeating the same year before graduation: 23; changing faculty: 13; dropping out: 19; and being expelled: 5. The 106 students who graduated without repeating the same year were classified into the graduation without repeating group. The 23 students who repeated the same year before graduation were classified into the graduation with repeating group. Similarly, the 37 students who changed faculty, dropped out, or were expelled were classified into the dropout group. In the dropout group, the period from entrance to dropping out was as follows: 6 months: 4; 12 months: 9; 18 months: 3; 24 months: 12; 30 months: 0; 36 months: 5; and 48 months or longer: 4 (mean ± standard deviation: 23 ± 13 months). Concerning the entrance examinations taken by the 166 students, we collected the following data through the Entrance Examination Center according to the given procedure: the type of entrance examination (entrance examination based on public recommendation, special entrance examination for Kobe Gakuin University Senior High School, entrance examination based on recommendation for designated schools, general entrance examination, and entrance examination by the National Center for University Entrance Examinations); rating score (full score: 5) at senior high school; score for English as the first written test, elective subject selected (from Japanese, Mathematics, and Science) as the second written test, and score for this subject in the entrance examination; and sex. It should be noted that among these types of entrance examination, the special entrance examination for Kobe Gakuin University Senior High School and entrance examination based on recommendation for designated schools include an interview, but no written test. Furthermore, as information about the 166 students after entrance into the university, we collected the names of the subjects they took and their grades for these subjects through the Educational Affairs Center, following the given procedure.

Then, we compared the sex and entrance examination-related data among the three groups (the graduate without repeating group, the graduate with repeating group, and dropout group).

We examined the numbers of subjects available and students for each subject attribute (common education subjects, specialized required subjects, and specialized elective subjects) in each of semesters 1-8.

As the number of students for each subject attribute shows, most of the students included in the study had been evaluated on their performance in specialized required subjects. Therefore, we calculated grade points for specialized required subjects available in semesters 1-8, and compared these values among the 3 groups: graduation with and without repeating and dropout.

As information regarding the students' subsequent academic performance, their grades, S, A, B, C, D, and "/", for each subject taken were scored 4, 3, 2, 1, 0, and 0, respectively, as grade points. Each student's grade point average (GPA) was calculated from his/her grade point for each relevant subject using the following formula: (Σ grade point for each subject × number of credits) / (Σ number of credits from each subject).

We compared GPAs calculated from grade points for specialized required subjects in each of semesters 1-4 among the 3 groups. The reason for limiting the target period to semesters 1-4 was that most students in the dropout group did not belong to this department after semester 4.

For the statistical analysis, we examined continuous variables using the Shapiro-Wilk test to confirm data

normality. When the data were normal, we initially used one-way analysis of variance. When finding differences among the 3 groups, we then compared 2 groups using the Bonferroni test in each case. When the Shapiro-Wilk test did not confirm data normality, we initially used the Kruskal-Wallis test. When finding differences among the 3 groups, we then compared 2 groups using the Mann-Whitney U test after Bonferroni correction in each case. For nominal variables, we used the chi-square test. We set the significance level at lower than 5%.

To compare the GPA for specialized required subjects among the three groups, we used receiver operating characteristic (ROC) curves to calculate the area under the curve (AUC), cut off point, sensitivity, and specificity from 1 to 4 semester. We used the statistical software IBM SPSS Statistics Ver. 28.

As for the explanation for subjects and their consent, we first obtained approval for the following points from the Ethics Committee for Research Involving Humans at the Faculty of Rehabilitation, Kobe Gakuin University (approval number: SORIN 20-15), and then shared this information on the website of the university: 1) the purpose and method of information use, 2) details of the information used, 3) scope of persons who use the information, 4) the name, institution, and contact address of the principal investigator, 5) term of information use, 6) disuse of information that allows the identification of subjects, and 7) the method to manage requests/claims from the subjects specified in 6) or their representatives.

III. RESULTS

There were no significant differences in sex and the type of entrance examination among the three groups (Table 1).

Similarly, there were no significant differences among them in the rating score at senior high school, and an elective subject as the second written tests. However, the dropout group's score for English was higher than the graduation with and without repeating groups (Table 2).

Table 3 shows the numbers of subjects available and students for each subject attribute, making it clear that all students included in the study had taken specialized required subjects and been evaluated on their performance in these subjects.

In semesters 1-8, grade points for many specialized required subjects varied among the 3 groups. There were no differences in grade points among the 3 groups for 2 of the 43 specialized required subjects in semesters 1-4 and 16 of the 28 in semesters 5-8. In semesters 1-4, the dropout group's grade points for 23 of the 43 specialized required subjects were lower than the graduation without repeating group. On the other hand, during this period, there were no differences in the values between the dropout and graduation with repeating group (Table 4).

Specialized required subject GPAs varied among the 3 groups in all semesters from 1 to 4. From semester 5 onward, there were fewer students in the dropout group. The dropout group's specialized required subject GPAs were lower than the graduation without repeating group in all semesters from 1 to 4. On the other hand, during this period, there were no differences in the values between the dropout and graduation with repeating group (Table 5).

The results of ROC analysis to confirm the identifiability of students at risk of dropping out and those who are likely to graduate with/without repeating the same year were as follows: First, the AUC between the graduation with and without repeating groups ranged from 0.79 in semester 1 to 0.91 in semester 2. Second, the AUC between the graduation without repeating and dropout groups ranged from 0.73 in semester 3 to 0.76 in semester 4. And third, the AUC between the graduation with repeating and dropout groups ranged from 0.50 in semester 1 to 0.68 in semesters 2 and 3 (Table 6).

Table 1. Comparison Based on Sex and the Type of Entrance Examination

Sex and Type of entrance examination	①Graduated students without repeat	②Graduated students with repeat	③Drop out students	p value		
				①vs②	①vs③	②vs③
Sex（male : female）	38:68	12:11	16:21	0.13	0.42	0.50
Entrance examination based on recommendation for designated schools（n=42）	29	5	8			
Entrance examination based on public recommendation（n=85）	57	11	17			
Special entrance examination for Kobe Gakuin University Senior High School（n=12）	5	4	3	0.30	0.45	0.58
General entrance examination（n=26）	14	3	9			
Entrance examination by the National Center for University Entrance Examinations（n=1）	1	0	0			

Values are students number　　vs: versus

Table 2. Comparison of Senior High School Rating Scores and Entrance Examination Written Test Scores

	①Graduated students without repeat	②Graduated with repeat students	③Drop out students	p-value			
				①vs②vs③	①vs②	①vs③	②vs③
Rating score	3.97 ± 0.53（n=106）	3.71 ± 0.51（n=23）	3.91 ± 0.43 (n=37）	0.14			
First written test (English)	53.17 ± 7.91（n=71）	51.56 ± 6.91(n=14)	58.24 ± 8.52 (n=26)	<0.01**	0.98	<0.05*	<0.05*
Second written test	53.40 ± 7.54 (n=68)	54.45 ± 7.65(n=12)	55.50 ± 8.65 (n=25)	0.69			

Values are expressed as mean ± SD　　p<0.05* p<0.01**　　vs: versus

Table 3. The numbers of subjects available and students for each subject attribute

semester	subject attribute	①number of subjects	②subjects taken by students	enrollment students
1	specialized required subjects	10	10	166.00 ± 0.00
	specialized elective subjects	1	1	165.00 ± 0.00
	common education subjects	19	17	54.65 ± 57.76
2	specialized required subjects	9	9	153.56 ± 1.33
	specialized elective subjects	2	2	46.00 ± 55.15
	common education subjects	45	35	14.91 ± 37.02
3	specialized required subjects	12	12	144.58 ± 4.01
	specialized elective subjects	3	3	54.33 ± 68.60
	common education subjects	43	11	1.27 ± 0.47
4	specialized required subjects	12	12	139.42 ± 1.24
	specialized elective subjects	0	0	0
	common education subjects	20	9	1.00 ± 0.00
5	specialized required subjects	14	14	131.93 ± 0.27
	specialized elective subjects	4	4	77.75 ± 51.75
	common education subjects	9	0	0
6	specialized required subjects	9	9	131.00 ± 0.00
	specialized elective subjects	4	4	50.50 ± 57.30
	common education subjects	9	0	0
7	specialized required subjects	2	2	129.00 ± 0.00
	specialized elective subjects	0	0	0
	common education subjects	0	0	0
8	specialized required subjects	3	3	129.00 ± 0.00
	specialized elective subjects	0	0	0
	common education subjects	0	0	0

Table 4. Comparison of Grade Points for Specialized Required Subjects

Semester	Subjects (the number of credits)	①Graduation without repeat group	②Graduation with repeat group	③Drop out group	p value			
					①vs②vs③	①vs②	①vs③	②vs③
1	Introduction to Occupational Therapy Exercise (1)	2.91 ± 0.47 (n=106)	2.82 ± 0.55 (n=23)	2.62 ± 0.76 (n=37)	<0.05*	0.22	0.09	1.00
	Psychology (2)	2.00 ± 0.72 (n=106)	1.52 ± 0.51 (n=23)	1.84 ± 0.83 (n=37)	<0.05*	<0.05*	1.00	0.14
	Exercise in Physics of Body Movement I(1)	1.23 ± 0.46 (n=106)	1.22 ± 0.42 (n=23)	0.97 ± 0.37 (n=37)	<0.05*	1.00	<0.05*	0.10
	Anatomy I (2)	1.92 ± 0.98 (n=106)	0.87 ± 0.82 (n=23)	1.00 ± 0.97 (n=37)	<0.01**	<0.01**	<0.01**	1.00
	Comprehensive Rehabilitation (2)	3.05 ± 0.68 (n=106)	2.65 ± 0.78 (n=23)	2.78 ± 0.92 (n=37)	<0.05*	0.80	0.30	1.00
	Introduction to Occupational Therapy (1)	2.60 ± 0.81 (n=106)	2.35 ± 0.71 (n=23)	1.89 ± 1.08 (n=37)	<0.01**	0.55	<0.01**	0.43
	Occupational activity studies (1)	2.28 ± 0.80 (n=106)	2.22 ± 0.85 (n=23)	1.84 ± 0.80 (n=37)	<0.05*	1.00	<0.05*	0.22
	Practice of occupational activity studies I (2)	2.91 ± 0.33 (n=106)	2.91 ± 0.42 (n=23)	2.70 ± 0.81 (n=37)	0.31			
	Practice of occupational activity studies II (1)	3.26 ± 0.93 (n=106)	3.00 ± 1.04 (n=23)	2.76 ± 1.19 (n=37)	<0.05*	0.72	<0.05*	1.00
	Observation practice of occupational therapy (1)	3.11 ± 0.75 (n=106)	2.87 ± 1.10 (n=23)	2.38 ± 1.26 (n=37)	<0.01**	1.00	<0.01**	0.13
2	Anatomy II (2)	2.02 ± 1.17 (n=106)	0.87 ± 0.63 (n=23)	1.28 ± 1.43 (n=25)	<0.01**	<0.01**	<0.01**	1.00
	Anatomy practice (2)	2.09 ± 0.63 (n=106)	1.43 ± 0.59 (n=23)	1.67 ± 0.66 (n=21)	<0.01**	<0.01**	<0.05*	0.70
	Physiology I (2)	1.92 ± 0.87 (n=106)	1.00 ± 0.52 (n=23)	1.28 ± 0.79 (n=25)	<0.01**	<0.01**	<0.01**	0.70
	Human Development (2)	2.84 ± 0.78 (n=106)	2.09 ± 0.95 (n=23)	2.12 ± 1.13 (n=25)	<0.01**	<0.01**	<0.01**	1.00
	Kinesiology (2)	2.58 ± 0.97 (n=106)	1.22 ± 0.10 (n=23)	1.48 ± 1.09 (n=25)	<0.01**	<0.01**	<0.01**	1.00
	Clinical psychology (1)	2.42 ± 0.90 (n=106)	1.83 ± 0.72 (n=23)	2.00 ± 1.08 (n=25)	<0.01**	<0.05*	0.17	1.00
	Human rights and medical care (1)	2.24 ± 1.02 (n=106)	1.57 ± 0.90 (n=23)	1.92 ± 1.04 (n=25)	<0.05*	<0.01**	0.66	0.47
	Practice of occupational activity studies III (1)	2.72 ± 0.87 (n=106)	2.00 ± 0.95 (n=23)	1.80 ± 0.96 (n=25)	<0.01**	<0.01**	<0.01**	1.00
	Public health (1)	2.87 ± 0.69 (n=106)	2.22 ± 0.74 (n=23)	2.20 ± 1.12 (n=25)	<0.01**	<0.01**	<0.01**	1.00
3	Physiology practice (2)	2.45 ± 0.69 (n=106)	1.70 ± 0.70 (n=23)	2.12 ± 0.78 (n=17)	<0.01**	<0.01**	0.32	0.25
	Practice of Occupational Therapy Kinesiology (1)	2.69 ± 0.88 (n=106)	1.91 ± 0.60 (n=23)	1.75 ± 0.78 (n=16)	<0.01**	<0.01**	<0.01**	1.00
	Internal Medicine I (1)	1.86 ± 0.79 (n=106)	1.52 ± 0.67 (n=23)	1.41 ± 0.71 (n=17)	<0.01**	0.19	0.12	1.00
	Orthopedic Surgery I (1)	1.42 ± 0.67 (n=106)	0.87 ± 0.46 (n=23)	0.76 ± 0.75 (n=17)	<0.01**	<0.01**	<0.01**	1.00
	General theory of Psychiatry (2)	2.56 ± 0.84 (n=106)	1.87 ± 0.92 (n=23)	2.12 ± 0.93 (n=17)	<0.01**	<0.01**	0.21	1.00
	Developmental Disabilities (2)	2.78 ± 0.76 (n=106)	1.91 ± 0.95 (n=23)	2.41 ± 0.71 (n=17)	<0.01**	<0.01**	0.32	0.22
	Pathology (2)	2.19 ± 0.94 (n=106)	1.13 ± 0.63 (n=23)	1.59 ± 1.12 (n=17)	<0.01**	<0.01**	0.10	0.30
	Occupation and Science (1)	2.58 ± 0.75 (n=106)	2.09 ± 0.85 (n=23)	1.94 ± 0.90 (n=17)	<0.01**	<0.05*	<0.05*	1.00
	Physical disability assessment (1)	2.58 ± 0.95 (n=106)	1.87 ± 0.87 (n=23)	2.06 ± 0.75 (n=17)	<0.01**	<0.01**	0.12	1.00
	Mental disorder assessment (1)	2.40 ± 0.82 (n=106)	1.91 ± 0.85 (n=23)	2.13 ± 0.92 (n=15)	<0.05*	0.06	0.74	1.00
	Developmental Disabilities Assessment (1)	2.68 ± 0.91 (n=106)	1.61 ± 0.78 (n=23)	1.76 ± 0.90 (n=17)	<0.01**	<0.01**	<0.01**	1.00
	Activities of Daily Living (1)	2.01 ± 1.01 (n=106)	1.48 ± 0.67 (n=23)	2.12 ± 0.99 (n=17)	<0.05*	0.07	1.00	0.09
4	Internal Medicine II (1)	1.91 ± 0.78 (n=106)	1.26 ± 0.45 (n=23)	1.18 ± 1.17 (n=11)	<0.01**	<0.01**	<0.05*	1.00
	Orthopedic Surgery II (1)	1.56 ± 0.66 (n=106)	1.04 ± 0.56 (n=23)	0.82 ± 0.75 (n=11)	<0.01**	<0.01**	<0.05*	1.00
	Mental Disorders I (1)	2.43 ± 1.05 (n=106)	1.96 ± 1.07 (n=23)	1.64 ± 1.12 (n=11)	<0.05*	0.18	0.10	1.00
	Mental Disorders II (1)	2.70 ± 1.17 (n=106)	2.74 ± 1.14 (n=23)	2.45 ± 1.57 (n=11)	0.93			
	Clinical neurology I (1)	2.16 ± 0.82 (n=106)	1.48 ± 0.90 (n=23)	2.09 ± 0.70 (n=11)	<0.01**	<0.01**	1.00	0.10
	Clinical neurology II (1)	2.72 ± 1.03 (n=106)	1.91 ± 0.95 (n=23)	2.27 ± 1.68 (n=11)	<0.01**	<0.01**	1.00	0.67
	Basic Theory of Occupational Therapy (1)	2.49 ± 0.80 (n=106)	1.87 ± 0.76 (n=23)	2.10 ± 0.57 (n=10)	<0.01**	<0.01**	0.35	1.00
	Exercise in Physical Disability Evaluation (1)	2.89 ± 0.84 (n=106)	1.57 ± 0.73 (n=23)	1.64 ± 0.92 (n=11)	<0.01**	<0.01**	<0.01**	1.00
	Exercise in Mental Disability Evaluation (1)	2.59 ± 0.78 (n=106)	2.00 ± 0.52 (n=23)	1.44 ± 1.13 (n= 9)	<0.01**	<0.01**	<0.01**	1.00
	Exercise in Developmental Disabilities Evaluation (1)	2.65 ± 0.98 (n=106)	1.70 ± 0.88 (n=23)	1.55 ± 1.13 (n=11)	<0.01**	<0.01**	<0.05*	1.00
	Practice in Activities of Daily Living I (1)	2.56 ± 0.83 (n=106)	2.09 ± 0.79 (n=23)	1.36 ± 0.81 (n=11)	<0.01**	0.08	<0.01**	0.15
	Occupational therapy clinical practice I (2)	3.21 ± 0.79 (n=106)	2.39 ± 1.16 (n=23)	1.86 ± 1.86 (n=7)	<0.01**	<0.01**	0.12	1.00
5	Rehabilitation Medicine (2)	2.10 ± 1.19 (n=106)	1.70 ± 1.15 (n=23)	3.33 ± 1.16 (n=3)	<0.05*	0.22	0.26	0.65
	Medical Safety Management Theory (1)	3.62 ± 0.75 (n=106)	3.43 ± 0.90 (n=23)	3.00 ± 1.00 (n=3)	0.18			
	Occupational Therapy Research I (2)	3.00 ± 0.00 (n=106)	3.00 ± 0.00 (n=23)	3.00 ± 0.00 (n=3)	1			
	Comprehensive training in occupational therapy evaluatio	2.70 ± 0.95 (n=106)	1.78 ± 1.00 (n=23)	3.00 ± 0.00 (n=3)	<0.01**	<0.01**	1.00	0.16
	Practice in Activities of Daily Living II (1)	2.26 ± 0.91 (n=106)	2.04 ± 0.83 (n=23)	2.26 ± 0.58 (n=3)	0.35			
	Technical Theory of Welfare Appliance Support (1)	3.31 ± 0.58 (n=106)	3.48 ± 0.59 (n=23)	3.33 ± 0.58 (n=3)	0.42			
	Physical Disability Therapy I (1)	2.45 ± 0.90 (n=106)	1.78 ± 0.74 (n=23)	2.67 ± 0.58 (n=3)	<0.01**	<0.01**	1.00	0.28
	Physical Disability Therapy II (1)	2.46 ± 1.00 (n=106)	1.96 ± 0.88 (n=23)	2.00 ± 1.00 (n=3)	0.07			
	Psychiatric Disorder Therapy (1)	2.51 ± 0.77 (n=106)	2.17 ± 0.72 (n=23)	2.67 ± 1.16 (n=3)	0.12			
	Developmental Disorders Therapy (1)	1.97 ± 0.93 (n=106)	1.61 ± 0.89 (n=23)	1.10 ± 0.00 (n=3)	<0.05*	0.22	0.18	0.78
	Therapy for geriatric disorders (1)	2.44 ± 0.66 (n=106)	2.30 ± 0.77 (n=23)	2.67 ± 0.58 (n=3)	0.65			
	Prosthetics (1)	2.31 ± 1.05 (n=106)	1.65 ± 0.89 (n=23)	2.67 ± 1.53 (n=3)	<0.05*	<0.05*	1.00	0.40
	Prosthetics Practice (1)	2.75 ± 0.78 (n=106)	2.13 ± 0.97 (n=23)	3.00 ± 0.00 (n=2)	<0.05*	<0.05*	1.00	0.53
	Regional Occupational Therapy (1)	2.65 ± 0.77 (n=106)	2.65 ± 0.83 (n=23)	2.00 ± 1.00 (n=3)	0.42			
6	Occupational Therapy Reserch II (2)	3.03 ± 0.17 (n=106)	3.00 ± 0.00 (n=23)	3.00 ± 0.00 (n=2)	0.70			
	Practice of clinical skills in occupational therapy (2)	2.19 ± 0.64 (n=106)	1.83 ± 0.84 (n=23)	2.00 ± 1.41 (n=2)	0.07			
	Practice on Welfare Appliance Support Techniques (1)	2.69 ± 0.77 (n=106)	2.43 ± 0.95 (n=23)	2.50 ± 0.71 (n=2)	0.43			
	Theory of career and life support (1)	2.88 ± 0.87 (n=106)	2.48 ± 0.95 (n=23)	1.50 ± 0.71 (n=2)	<0.05*	0.15	0.13	0.55
	Practice of physical disability therapy (1)	2.65 ± 0.88 (n=106)	2.04 ± 0.64 (n=23)	3.00 ± 1.41 (n=2)	<0.01**	<0.01**	1.00	0.51
	Practice of mental disability therapy (1)	2.62 ± 0.67 (n=106)	2.30 ± 0.70 (n=23)	2.00 ± 0.00 (n=2)	0.08			
	Practice of developmental disability therapy (1)	1.40 ± 0.60 (n=106)	2.22 ± 0.42 (n=23)	1.00 ± 0.00 (n=2)	0.29			
	Practice of geriatric disability therapy (1)	2.73 ± 0.51 (n=106)	2.52 ± 0.67 (n=23)	2.00 ± 0.41 (n=2)	0.18			
	Practice of Regional Occupational Therapy (2)	3.25 ± 0.44 (n=106)	3.13 ± 0.34 (n=23)	3.00 ± 0.55 (n=2)	0.32			
7	Clinical practice of occupational therapy IIa (9)	2.74 ± 0.64 (n=106)	2.17 ± 0.78 (n=23)	/	<0.01**	<0.01**	/	/
	Clinical practice of occupational therapy IIb (9)	2.62 ± 0.75 (n=106)	2.04 ± 1.22 (n=23)	/	<0.05*	<0.05*	/	/
8	Medical welfare cooperation theory (1)	3.37 ± 0.57 (n=106)	3.65 ± 0.49 (n=23)	/	<0.05*	<0.05*	/	/
	Manegement of Occupational Therapy (1)	2.42 ± 1.15 (n=106)	3.48 ± 0.85 (n=23)	/	<0.01**	<0.01**	/	/
	Comprehensive Exercise in Occupational Therapy (1)	2.51 ± 1.00 (n=106)	2.13 ± 1.22 (n=23)	/	0.09			

Values are expressed as mean ± SD p<0.05* p<0.01** vs:versus

Table 5. Comparison of GPAs for required subjects in three groups

semester	①Graduated without repeat group	②Graduated with repeat group	③Drop out group	p-value			
				①vs②vs③	①vs②	①vs③	②vs③
1	2.51 ± 0.31 (n=106)	2.16 ± 0.28（n=23）	2.08 ± 0.60 (n=37)	<0.01**	<0.01**	<0.01**	1.00
2	2.37 ± 0.54 (n=106)	1.49 ± 0.39（n=23）	1.87 ± 0.62 (n=21)	<0.01**	<0.01**	<0.01**	0.13
3	2.39 ± 0.46 (n=106)	1.65 ± 0.46（n=23）	1.93 ± 0.48 (n=15)	<0.01**	<0.01**	<0.01**	0.22
4	2.54 ±0 .44 (n=106)	1.88 ± 0.39（n=23）	1.84 ± 0.86 (n=7)	<0.01**	<0.01**	<0.01**	1.00
5	2.58 ± 0.44 (n=106)	2.23 ± 0.37（n=23）	2.68 ± 0.07 (n=3)	<0.01**	<0.01**	1.00	0.19
6	2.66 ± 0.25 (n=106)	2.41 ± 0.31（n=23）	2.33 ± 0.59 (n=2)	<0.01**	<0.01**	1.00	1.00
7	2.68 ± 0.49 (n=106)	2.11 ± 0.83（n=23）	/	/	<0.01**	/	/
8	2.76 ± 0.63 (n=106)	3.09 ± 0.50（n=23）	/	/	<0.05*	/	/

Values are expressed as mean ± SD
p<0.05* p<0.01**
vs: versus

Table 6. AUC,cut off point, sensitivity, specificity by using ROC curve

	semester	AUC	cut off point	sensitivity	specificity
students without repeat vs students with repeat	1	0.79	2.39	0.660	0.826
	2	0.91	1.82	0.840	0.870
	3	0.87	1.84	0.887	0.696
	4	0.88	2.27	0.726	0.957
students without repeat vs drop out students	1	0.75	2.11	0.906	0.460
	2	0.74	1.89	0.821	0.619
	3	0.73	2.28	0.575	0.800
	4	0.76	2.12	0.821	0.714
students with repeat vs drop out students	1	0.50	1.68	0.957	0.189
	2	0.68	1.39	0.810	0.522
	3	0.68	1.91	0.600	0.739
	4	0.53	1.92	0.714	0.478

vs: versus
AUC takes values from 0 to 1, with values closer to 1 indicating higher discrimination

IV. DISCUSSION

Among the 166 students included in the study, there were 106 in the graduation without repeating group, 23 in the graduation with repeating group, and 37 in the dropout group. Thus, the dropout rate was 22.3%. In a survey conducted by the Ministry of Health, Labour, and Welfare, the dropout rate was 12.5%1). The rate in the Department of Occupational Therapy of the study university was slightly higher than this. There are many reasons for dropping out after entering university. The Ministry of Education, Culture, Sports, Science, and Technology highlights maladjustment to school life as one of such reasons[4]. In Japan, occupational therapists are recognized as "professionals with many chances of finding work". However, Senba et al. noted that being required to gain a large number of credits, attend classes for long hours, and develop high ethical standards after admission, occupational therapy students tend to experience stress associated with these tasks other than acquiring expertise[5]. Routinely learning at the Department of Occupational Therapy while being required to acquire extensive specialized knowledge and high ethical standards, students may feel a gap between the goals to be achieved and their own motivation for admission, and choose to drop out.

On comparing entrance examination scores among the graduation without repeating, graduation with repeating, and dropout groups, there were no significant differences in rating scores at senior high school. And the second written test scores in the entrance examination. On the other hand, the dropout group's score for English as the first written test was higher than the graduation with and without repeating groups. Shiyue He et al. reported that the entrance examination score for English is correlated with academic performance after admission[6], whereas Melanie D. Lugo et al. noted that the impact of entrance examination scores on academic performance after admission is limited, and they are important only in terms of student acceptance[7]. Sarah Louise McGinley et al. also reported that there was no correlation between occupational therapy students' pre-admission performance and final degree outcomes[8]. Among the students included in the present study, 66.9% received written tests in the entrance examination. As we did not evaluate all of these students, the results should be considered only as a reference, but we do not consider that this is strongly related to the 3 groups, graduation with and without repeating and dropout, as the outcomes.

All of these students had been evaluated on their performance in specialized required subjects. The curriculum used by the Department of Occupational Therapy, Kobe Gakuin University, is based on the laws established by the government. Students at this department are required to acquire a minimum of 124 credits for graduation. Among the 124 credits, 106 are allocated to specialized required subjects required for graduation[9]. In contrast, common education subjects and specialized elective subjects aim to help students acquire general liberal arts knowledge and desirable knowledge, but they are not required to be acquired. The difference between required and elective subjects, which is a characteristic of the subject registration process incorporated into the curriculum, may have influenced the number of students.

Previous studies on GPA reported a positive correlation between academic performance in the first year and at the time of graduation, emphasizing the importance of performance soon after admission[10-12]. At the Department of Occupational Therapy of the study university, the dropout group's academic performance (specialized required subject GPAs) was poorer than the graduation without repeating group soon after admission (semester 1). Those required to take in semester 1 are basic subjects, such as anatomy and physiology, which are not studied at high school, but are important to become an occupational therapist. We speculate that some students struggle with anatomy, physiology, and other basic subjects due to the amounts of learning these require and their levels of difficulty. Moreover, in a previous study involving students in the Department of Physical Therapy of the study university, the graduation with repeating group's specialized required subject GPAs were lower than the graduation without repeating group and higher than the dropout group[13]. However, at the Department of Occupational Therapy, there were no differences in specialized required subject GPAs between the dropout and graduation with repeating groups, suggesting that students in the former do not necessarily choose to change faculty or drop out only

due to poor academic performance. Kaneko et al. observed that when facing the reality after admission, represented by a large number of required subjects and a curriculum with little flexibility, some students are unable to adapt to university life due to a sense of discomfort caused by a discrepancy between expectations and such a reality, and consequently drop out[14].

In ROC analysis between the dropout and graduation without repeating groups, the AUC was 0.7 or greater in all semesters from 1 to 4. With regard to the AUC, Anthony K. Akobeng defined that an AUC of 0.9 or greater is highly accurate, 0.7-0.9 is moderately accurate, 0.5-0.7 is inaccurate, and 0.5 is a coincidental result[15]. These findings confirm that the use of specialized required subject GPAs in each semester makes it possible to identify students at risk of dropping out with moderate accuracy from semester 1.

The Department of Occupational Therapy, Kobe Gakuin University, should provide feedback to students with poor academic performance through interviews at the end of semester 1. The important point during these interviews is informing students that their scores are below the cutoffs, and that they have an increased risk of repeating the same year or even dropping out in the future. It is necessary to continuously stimulate students' motivation to learn, and promote their self-directed learning, with the aim of improving their academic performance. Support from faculty members is required to confirm students' learning goals and achievement levels[16]. In education to become an occupational therapist, there are certainly some points where students need to change their own attitudes toward learning[17]. In this respect, approaches to improve their academic performance, including increasing their motivation for learning and guiding them toward appropriate learning methods based on specific data, such as those shown in the present study, are required. We believe that improved student performance will help produce better occupational therapists who meet social needs related to current healthcare services.

As a study limitation, this study involved only students in the Department of Occupational Therapy, Kobe Gakuin University, and, therefore, it is unclear whether the same results can be obtained by examining GPAs in other schools with different student and curriculum characteristics. To confirm GPA versatility, further studies should be conducted in other schools and departments. In addition, several previous studies suggest that student performance is complicated by a variety of issues, including motivation to learn and interpersonal relationships, as well as learning ability[18 - 20]. The relationship between motivation to learn and grades needs to be a topic of future research in order to improve student performance.

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