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ORIGINAL ARTICLE

EFFECTS OF THE FIRST TRAINING SESSION ON THE PHYSIOLOGICAL AND MENTAL CONDITIONS IN MALE UNIVERSITY FRESHMEN JUDOISTS

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Abstract The changes in the anthropometric and blood biochemical parameters, neutrophil functions such as reactive oxygen species (ROS) production capability, phagocytic activity (PA) and the profile of mood state (POMS) were measured after 2-hours of judo training session for 24 male university freshmen judoists who had not done any training for a long period. As for neutrophil function, PA significantly decreased after the training compared with the pre-value, though ROS production capability did not change. The Depression, Tension and total mood disturbance (TMD) decreased significantly after the training. Furthermore, the change in blood sugar correlated positively with the changes in the Depression, Fatigue and TMD. The change in creatine kinase was positively associated with the change in the Confusion. The training negatively acted on the appearance of physiological fatigue, and positively acted on the appearance of mental fatigue, and some relationship between both. Furthermore, the typical response of the neutrophil function (PA decrease and no change in ROS) does not coincide with the typical neutrophil compensation pattern e.g. PA decrease and ROS increase may be due to the lack of training on the part of the subjects for the last 6 months.

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Key words: Judo training; POMS; physiological condition; mental condition; freshman.

原　著

大学柔道部新入部員の最初のトレーニングが心身のコンディションに及ぼす影響

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抄録　長期間トレーニングを行わなかった大学柔道部新入部員24名を対象として，練習前後の血液生化学データ，好中球機能すなわち活性酸素種(ROS)産生能および貪食能，profile of mood state (POMS)における変化を測定した．練習後における血糖，総コレステロール，中性脂肪，ヘモグロビン，IgA，IgM，補体(C3・C4)は練習前と比較して有意に減少したが，尿酸，筋逸脱酵素，好中球数は増加した．好中球機能では，練習前後でROS産生能は変化せず，貪食能は有意に低下した．さらに，血糖の変化は抑うつ，疲労，TMDの変化と正相関を示し，クレアチンキナーゼの変化は混乱の変化と正相関を示しており，トレーニングは身体的疲労を惹起し，精神的疲労に良好な影響を与えていることが明らかとなった．さらに，本研究で観察された好中球機能の変化は，典型的な好中球機能の代償パターンとは一致せず，これは長期間のトレーニング未施行が原因であると考えられた．

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キーワード：柔道トレーニング；POMS；身体的コンディション；精神的コンディション；新入部員．

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Introduction

Many studies have clarified that a bout of prolonged and high intensity exercise performed by athletes has the potential to cause dehydration, renal failure, the loss of serum electrolytes, the consumption of serum glucose and lipids and the increase of protein catabolism in muscular tissue in accordance with an increase in energy metabolism, muscular damage and immunosuppression[1-7]. Similarly, it has been reported that exercise induces mental fatigue in participating athletes[8]. It has also been suggested that the risk of developing the so-called over training syndrome and the overuse syndrome increases in athletes when the training is repeated without allowing for appropriate recovery during resting periods from the combination of physiological and mental fatigues caused by a bout of exercise[9-11].

Research studies in the fields of sports medicine and sports science use items such as blood biochemistry, measurement of physical fitness including muscular power and various psychological tests to understand the physiological and mental conditions in athletes, and the characteristics of these parameters have been examined and validated[9-11]. In some previous studies, our group has also reported the effects of intense exercise and weight reduction in judoists, rugby players and marathon runners on the appearance of physiological and mental fatigue in order appropriately to manage these conditions and the health of the participating athletes[12-15]. These studies used biochemistry assays and neutrophil functions as indices of physiological condition and the profile of mood state (POMS) test as an index of mental condition[16]. The results of that group of studies corresponded with the results of the earlier studies already mentioned above[1-7]. Furthermore, based on these indices we were able to clarify that there was a significant relationship between the appearance of the physiological and mental fatigues caused by the exercise[13].

The accuracy and efficacy of the POMS test have been well-validated in previous studies as a simple psychological test to understand objectively the appearance and the accumulation of exercise-mediated mental fatigue in athletes, and we have also demonstrated the effectiveness of the POMS test in our previous study already referenced above[17-21]. However, it is possible that psychological tests, including the POMS test, can be influenced by various factors such as interindividual variations in personal psychological characteristics, the environment of daily life, the environment in which the training is performed, and the physiological condition of the subjects taking such tests. We thus considered it necessary to determine results of the POMS test in the light of these influences.

In this study, the influence on the male university freshmen judoists who had their first training session in a long time were examined by determining their physiological and mental conditions from various aspects, including biochemical results, neutrophil functions and the POMS test. The relationships among each parameter were also examined.

Methods

1. Subjects

The subjects of this investigation were 24 male university freshmen judoists who had just entered university. The average age of the subjects was 18.0 ± 0.2 years, the height was 171.0 ± 5.0 cm, the body weight (BW) was 82.4 ± 12.6 kg, the relative body fat (%fat) was 15.9 ± 3.9 %, and fat-free mass (FFM) was 68.9 ± 7.9 kg.

None of the subjects had done any training in the approximately 6-month period before starting university, and their entrance to university as freshmen had changed their daily environment, activities of daily life and the manner in which

the training was carried out. The first judo training session in which they participated after starting university was selected as the one for investigation in the present study. We measured the investigation items before (pre-value) and after the 2-hour quotidian judo training session, which consisted of 15 min. of warm-up for ; 20 min. of "*uchicomi*" (the same technique practiced repeatedly, such as throw down, push down and hook down); 70 min. of "*randori*" (exercise training in the form of a match); and 15 min. of cool-down. This training was classified as the irregular-interval training, and is a model of acute exercise.

The mean heart rate during the training was 128.8 ± 12.0 beats/min (bmp) and the maximum heart rate was 180.5 ± 14.0 bpm, recorded in the randori phase. The heart rate was measured and recorded at intervals of 15 seconds using VANTAGE XL (POLAR ELECTLIC Inc., Finland), and was analyzed at intervals of 1 minute after the end of the measurement using POLAR HR ANALYSIS SOFTWARE VER. 4 (POLAR ELECTLIC Inc., Finland).

The approval for the study was obtained from the Ethics Committee of Hirosaki University School of Medicine. The study protocol and purpose were explained to all the subjects, and written consent was obtained from them all.

2. Body composition

Anthropometric parameters measured the BW, the %fat, and the FFM with a TBF-110 system (TANITA, Tokyo, Japan) using the impedance method, after measuring height.

3. Blood chemistry parameters

Twenty milliliter samples of blood were collected from the forearm vein before and after the training. The collected blood samples were split up and allocated for measurement with the following methods. Five milliliters was used to analyze the hemocyte elements, 10 ml was used to analyze the serum elements and 5 ml was used to analyze the neutrophil function.

Leukocyte, neutrophil and hemoglobin (Hb), hematocrit (Ht) were determined from venous blood treated with ethylenediaminetetraacetic acid using an automatic blood cell counter (Sysmex K-2000, Kobe, Japan). Serum samples were separated from blood samples by centrifugation for 10 min at 3000 rpm and kept frozen at -30°C until used for measurement at a later date.

The measurement items of the serum elements were blood glucose (BG), total protein (TP), albumin (Alb), total cholesterol (TC), HDL-cholesterol (HDL-C), triglyceride (TG), free fatty acid (FFA), electrolytes (Na, K, Cl, Pi), creatinine (Cr), uric acid (UA), blood urea nitrogen (BUN), aspartate aminotransferase (AST), alanine aminotransferase (ALT), serum creatine kinase (CK), lactate dehydrogenase (LDH) immunoglobulins (IgG, IgA, IgM) and complements (C3, C4). The following methods were used: the ultraviolet (UV) method for AST, ALT, LDH, CK, and FFA; enzyme for BG, TC, HDL-C, TG, Pi, Cr and UA; biuret for TP; bromcresol green for Alb; glass electrode for Na, K and Cl; the turbidimetric immunoassay method for immunoglobulins and complements.

These values after the exercise were adjusted by the plasma volume calculated by the levels of Ht and Hb before and after the exercise because dehydration was observed in the changes of weight and Ht before and after the training[22].

4. POMS scores

The POMS test was used to evaluate exercise-related mental fatigue using the subscales *Tension* (Ten), *Depression* (Dep), *Anger* (Ang), *Vigor* (Vig), *Fatigue* (Fat), and *Confusion* (Con), assessed before and after the training camp[16]. *Total Mood Disturbance* (TMD) was calculated using the following formula: TMD =

(Ten+Dep+Ang+Fat+Con+100-Vig). The test was administered to all participants by the same trained interviewer.

5. Neutrophil oxidative burst activity (OBA) and phagocytic activity (PA)

These activities were measured with a FACScan system (Becton Dickinson, San Jose, CA) using two-color flow cytometry. Hydroethidine (HE: 44.4 μM, Polysience Inc., Warrington, PA) was used as an indicator for OBA (representing the ROS production capability), and opsonized zymosan particles (Sigma Chemical Co., St. Louis, MO) labeled with fluorescein isothiocyanate (FITC, Sigma) were used as indicators for PA.

In brief, 100 μl of heparinized whole blood was mixed with 22 μl of HE (final concentration; f.c. 8 μM), and incubated at 37°C for 5 min. After the addition of 25 μl of FITC-labeled opsonized zymosan (FITC-OZ, f.c. 5 mg/ml), the samples were incubated at 37℃ for 35 min. To measure basal oxidative burst activity, neutrophils labeled with only HE served as controls. After the incubation, Lyse and Fix (IMMUNOTECH, Marseille, France) were added to the red blood cells to fix the samples. The samples were washed twice in phosphate buffered saline with sodium azide (PBS+), and the fluorescence intensity (FI) in the activated neutrophils was measured with FACScan. Just before the assay, 30 μl of trypan blue (0.25 mg/ml, pH 4.5) was added to differentiate the attached from the ingested FITC-OZ in the samples following measurement by fluorescence quenching[23, 24]. The intensity of neutrophils expressing FITC-OZ and HE fluorescence were computed. Neutrophil OBA and PA were estimated as the mean channel number of the FI of activated neutrophils.

6. Statistical Analysis

All values were presented as means ± standard deviation. Differences in mean values for each BW, biochemistry item, neutrophil function and POMS scores before and after the training were tested with the generalized Wilcoxon-test. The relation between the changes in values of each measurement before and after the training was studied using Spearman's correlation coefficient. The differences were considered statistically significant at $P < 0.05$.

Results

A significant decrease in BW was observed after the training compared with the level before the training in the present study, and it suggested that dehydration appeared in our subjects (Table 1).

Serum BG, TC and TG significantly decreased after the training compared with the pre-values ($p<0.01$, $p<0.05$, $p<0.05$, respectively), and FFA increased ($p<0.01$) (Table 2). Hb and Ht significantly decreased after the training compared with the pre-values ($p<0.01$, in each) (Table 2). The levels of serum Na, K, Cl and Pi significantly decreased after the training compared with the pre-values ($p<0.01$, in each) (Table 2). Serum Cr, UA, AST, CK and LDH significantly increased after the training compared with the pre-values ($p<0.01$, in each) (Table 2). Leukocyte and neutrophil counts significantly increased after the training compared with the pre-values, and IgA, IgM, C3 and C4 decreased ($p<0.01$, in each) (Table 2).

As for the neutrophil function, neutrophil PA significantly decreased after the training compared with the pre-value ($p<0.01$), though neutrophil OBA did not change (Table 3).

In the POMS scores, the Dep, Ten and TMD scores significantly decreased after the training compared with the pre-values ($p<0.05$, $p<0.01$, $p<0.05$, respectively) (Table 4).

The relation between the changes in the POMS scores, biochemistry items and neutrophil functions before and after the training are

Table 1 Characteristics of study subjects and the change of body weight before and after the judo training (n=24).

	Before the training	After the training
Age (years)	18.0 ± 0.2	-
Height (cm)	171.0 ± 5.1	-
Body weight (kg)	82.4 ± 12.6	81.4 ± 12.7 **
Relative body fat (%)	15.9 ± 3.9	-
Fat-free mass (kg)	68.9 ± 7.9	-

Values are the mean ± standard deviation.
**: $p<0.01$, Significantly different from the value before the training.

Table 2 Changes in blood biochemical parameters (n=24).

	Before the training	After the training[a]
Leukocytes (/μl)	6104.2 ± 1389.6	9604.1 ± 1899.8 **
Neutrophils (/μl)	2845.5 ± 1195.4	7010.0 ± 1772.7 **
Hemoglobin (g/dl)	16.1 ± 0.6	15.7 ± 0.7 **
Hematocrit (%)	47.7 ± 1.8	46.5 ± 1.8 **
TP (g/dl)	7.5 ± 0.3	7.4 ± 0.4
Albumin (g/dl)	4.8 ± 0.2	4.8 ± 0.3
TC (mg/dl)	179.5 ± 32.4	170.7 ± 32.4 *
HDL-C (mg/dl)	63.0 ± 16.4	61.5 ± 16.5
TG (mg/dl)	87.0 ± 36.6	74.1 ± 25.9 *
FFA (mEq/dl)	0.4 ± 0.1	1.1 ± 0.4 **
BG (mg/dl)	91.0 ± 6.2	85.4 ± 11.8 **
UA (mg/dl)	6.0 ± 1.0	7.2 ± 1.4 **
BUN (mg/dl)	15.0 ± 2.3	15.1 ± 2.5
Cr (mg/dl)	1.0 ± 0.1	1.1 ± 0.2 **
AST (IU/l)	22.3 ± 7.1	25.7 ± 6.3 **
ALT (IU/l)	25.5 ± 14.8	25.7 ± 6.3
LDH (IU/l)	329.2 ± 41.0	432.7 ± 54.6 **
CK (IU/l)	200.3 ± 104.7	343.9 ± 137.3 **
IgG (mg/dl)	1290.4 ± 189.7	1261.7 ± 199.6
IgA (mg/dl)	216.0 ± 72.5	205.7 ± 68.4 **
IgM (mg/dl)	101.7 ± 32.2	97.3 ± 31.5 **
C3 (mg/dl)	107.2 ± 18.0	101.7 ± 18.2 **
C4 (mg/dl)	22.8 ± 4.6	21.4 ± 4.9 **
Na (mEq/l)	141.1 ± 1.3	134.6 ± 6.5 **
K (mEq/l)	4.4 ± 0.3	3.7 ± 0.3 **
Cl (mEq/l)	101.0 ± 1.5	96.4 ± 4.0 **
Pi (mg/dl)	4.2 ± 0.5	3.6 ± 0.7 **

Values are the mean ± standard deviation.
a: The values after the training were adjusted for dehydration by plasma volume.
*: $p<0.05$, **: $p<0.01$, Significantly different from the value before the training.

shown in Table 5. The change in BG correlated positively with the changes in the Dep, Fat and TMD scores ($p<0.05$, $p<0.05$, $p<0.01$, respectively). The change in HDL-C was positively associated with the changes in the Fat and TMD scores ($p<0.05$, in each). The changes in Hb and K correlated positively with the change in the Ang score ($p<0.05$, in each). The change in Cr was negatively related to the changes in the Con and TMD scores ($p<0.05$). The change in CK was positively associated with the change in the Con score ($p<0.05$).

Table 3 Changes in neutrophil functions (n=24).

	Before the training	After the training
Oxidative burst activity per cell (FI)	221.8 ± 29.9	209.6 ± 37.5
Phagocytic activity per cell (FI)	420.9 ± 58.7	292.6 ± 52.2 **

Values are the mean ± standard deviation.
**: $p<0.01$, Significantly different from the value before the training.

Table 4 Changes in scores in POMS (n=24).

	Before the training	After the training
Anger	11.6 ± 5.7	9.6 ± 5.6
Confusion	9.0 ± 3.4	8.3 ± 3.5
Depression	11.5 ± 7.4	8.6 ± 7.1 *
Fatigue	10.2 ± 5.3	8.8 ± 4.2
Tension	16.0 ± 5.1	12.8 ± 5.0 **
Vigor	12.2 ± 4.1	12.7 ± 5.5
TMD	146.2 ± 22.1	135.4 ± 20.2 *

Values are the mean ± standard deviation.
POMS: Profile of Mood State.
TMD: Total Mood Disturbance,
TMD=(Anger+Confusion+Depression+Fatigue+Tension+100-Vigor).
*: $p<0.05$, **: $p<0.01$, Significantly different from the value before the training.

Discussion

A bout of prolonged high intensity exercise has the potential to induce dehydration, renal failure, the loss of serum electrolytes, the consumption of serum glucose and lipids, and the increase of protein catabolism in muscular tissue in tandem with increasing energy metabolism, muscular damage and immunosuppression in participating athletes, as mentioned above[1-7]. These exercise-mediated changes in physiological conditions result in the induction of physiological fatigue in participating athletes.

In the present study, the decreases in BG, TC and TG, and the increase in FFA were observed after the training session, and suggested a training-mediated increase in of serum glucose and lipid metabolism[2, 7]. The decreases in Hb and Ht as seen in our results might be a consequence of damage to erythrocytes caused by the elevation of body temperature, oxidation in blood and an increase in physical impacts associated with performing the training regimen[25]. The decreases in Na, K, Cl and Pi after training observed in our results showed that serum electrolyte levels were lowered due to increased training-mediated perspiration[1, 6].

Some studies have already clarified that performing exercise brought about an increase of protein catabolism in muscle tissue concomitantly with increased energy metabolism and injury of and damage to muscle tissues[4, 5]. Serum myogenic enzymes are increased by exercise, and this increase has been well-accepted as an index of the degree of injury and damage to tissue in the study of sports medicine[26-28]. The rises in the levels of Cr, UA, AST, CK, and LDH after the training observed in our results suggested the increased protein catabolism in muscle tissue and the presence of muscle injury and damage generated in our subjects by the intense and prolonged exercise session.

Our results showed increases in leukocyte and neutrophil counts and decreased levels of

Table 5 Spearman's correlation coefficients between the change values in biochemical analyses, neutrophil functions and in the POMS scores before and after the training (n=24).

	Anger	Confusion	Depression	Fatigue	Tension	Vigor	TMD
Leukocytes (/μl)	-0.046	-0.154	-0.058	-0.011	-0.250	0.115	-0.195
Neutrophils (/μl)	-0.037	-0.177	-0.244	-0.082	-0.321	-0.006	-0.279
Hemoglobin (g/dl)	0.426 *	0.128	0.269	0.221	0.333	-0.025	0.394
Hematocrit (%)	-0.235	-0.394	-0.366	-0.164	-0.133	0.106	-0.309
TP (g/dl)	0.186	-0.020	0.061	0.036	0.153	0.016	0.210
Albumin (g/dl)	0.139	-0.162	-0.144	-0.048	0.021	0.123	-0.005
TC (mg/dl)	0.286	0.059	0.145	0.273	0.332	0.089	0.136
HDL-C (mg/dl)	0.316	0.149	0.327	0.454 *	0.367	0.076	0.428 *
TG (mg/dl)	0.206	-0.055	-0.051	0.349	-0.002	-0.203	0.150
FFA (mEq/dl)	0.035	-0.197	-0.185	0.291	0.017	-0.180	-0.058
BG (mg/dl)	0.190	0.274	0.528 *	0.475 *	0.369	-0.173	0.526 **
UA (mg/dl)	-0.024	-0.047	-0.223	0.136	-0.194	0.313	-0.211
BUN (mg/dl)	-0.005	-0.004	-0.002	0.230	0.086	-0.159	0.053
Cr (mg/dl)	-0.024	-0.528 *	-0.355	-0.156	-0.409	-0.023	-0.417 *
AST (IU/l)	0.144	-0.009	0.083	-0.133	0.017	-0.153	0.156
ALT (IU/l)	0.026	0.421	0.299	0.188	0.230	-0.154	0.336
LDH (IU/l)	0.186	-0.255	-0.166	-0.344	-0.401	0.027	0.192
CK (IU/l)	0.193	0.421 *	-0.016	-0.225	-0.295	0.033	-0.187
IgG (mg/dl)	0.100	-0.063	0.014	0.183	0.220	0.239	0.123
IgA (mg/dl)	0.156	-0.194	0.012	-0.036	0.118	0.158	0.056
IgM (mg/dl)	0.143	-0.038	-0.155	0.081	0.168	0.001	0.103
C3 (mg/dl)	0.057	-0.206	-0.026	-0.002	0.187	-0.059	0.105
C4 (mg/dl)	-0.074	-0.269	-0.046	-0.180	0.057	0.099	-0.038
Na (mEq/l)	0.199	0.012	-0.018	0.122	0.076	-0.023	0.152
K (mEq/l)	0.410 *	-0.044	0.010	0.098	0.136	0.159	0.168
Cl (mEq/l)	0.272	0.177	0.070	0.134	0.039	-0.013	0.188
Pi (mg/dl)	0.093	-0.209	0.114	0.173	0.119	-0.101	0.131
Oxidative burst activity per cell (FI)	0.092	0.095	-0.322	-0.105	0.034	-0.115	-0.115
Phagocytic activity per cell (FI)	0.215	0.374	-0.002	0.084	0.048	0.188	0.188

POMS: Profile of Mood State.
TMD: Total Mood Disturbance, TMD=(Anger+Confusion+Depression+Fatigue+Tension+100-Vigor).
*: $p<0.05$, **: $p<0.01$

IgA, IgM, C3, and C4 after the training. There is a possibility that these responses might be brought about as a result of the increased stress as a reaction to the training, and the anti-inflammatory reaction as a consequence of the training-mediated muscle injury and damage[29-31].

Mochida et al. suggested that major three neutrophil immune functions such as serum opsonic activity (SOA), ROS production capability and PA may compensate for each other to maintain the overall integrity of the neutrophil immune function, depending on the exercise loading and subject's physical condition, such as the degree of fatigue[32].

In previous studies including Mochida's report, the typical change in ROS production capability and PA from a single bout of normal exercise has been an increase in SOA and ROS whereas PA decreased[14, 32, 33]. However, under the conditions of severe and prolonged exercise such as a full marathon and a training camp plus weight reduction, neutrophil parameters have tended to deviate from such typical compensatory changes. For example, in some reports both PA and ROS decreased[12, 34].

In the present study, neutrophil PA

significantly decreased after the training, though neutrophil OBA did not change. This pattern does not coincide with the typical neutrophil compensation pattern. One possible explanation for this could be that our subjects had physiological weakness, because they started to participate in judo training for the first time after a 6-month period without training. Additionally, Yamamoto et al. reported that it took 2 months for the judoists who had stopped judo training for 6 months and restarted their training to regain the typical neutrophil response[35]. Therefore, our subjects' neutrophil response to judo training might also change back to the typical pattern after few months.

Highly intense and prolonged exercise does not only cause various aspects of physiological fatigue, but it also induces mental fatigue[8]. As we have previously reported, 90 minutes of exercise during one university rugby game led to a negative mental condition in players, and it was indicated by an increase of their TMD score after the game[21]. These reports therefore suggest that the intense exercise participated in by athletes as part of their training regimen or competition negatively acts on their mental condition. On the other hand, decreases in the Dep, Ten, and TMD scores were observed in our present study, suggesting that in fact the training session in which our subjects participated brought about a positive mental condition in them, which differs from the results of other previous studies.

One possible explanation for the difference between negative post-exercise POMS test results in previous studies and the positive findings in our current study could be that our subjects were extremely anxious about starting their new daily university life, and participating in judo training for the first time after a 6-month period without training. It could therefore be inferred that this unique situation (i.e., first judo training session for brand new freshmen) had an equally unique effect on the POMS scores. Another possible explanation for this is that physical activity causes the release of β-endorphin, which was responsible for the improved mood experienced by subjects after exercise[36, 37]. The increase in β-endorphin induced by exercise is related its intensity, and[38, 39] thus, a training can lower β-endorphin release by reducing the stress produced during exercise[40].

We could go further, and suggest that returning to a familiar training routine, although in an unfamiliar situation, helped raise the spirits of our subjects, because the initial POMS scores were probably artificially depressed due to the new situation, namely the change from a high school to a university environment and so on, and so the POMS scores improved. Therefore, when administering the POMS tests, careful observation of all environmental factors are recommended as they might bias the feelings of the examinees, and then interpret the results of the POMS test in the light of these factors.

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