〔東京家政大学研究紀要　第54集 (2), 2014, pp.7～12〕

Study on the physiological condition of female collegiate athletes in the Hokuriku region where situates at a heavy snowy area in Japan

Nanao,Yumiko* Nomura,Takahiro* and Ichimaru,Yuhei**

（Accepted for publication 12 December 2013）

キーワード：大学生女子スポーツ選手、シーズンオフ、体組成、体力、疲労
Key words：female collegiate athletes, off season conditioning, body composition, physical strength, Fatigue

Introduction

Athletes need to be in optimal condition at the start of the season and this is achieved by training according to specific programs throughout each year. Thus, many studies have described the importance of physical conditioning during the off-season[1)2)3)]. A study of collegiate sport players found that increased fat storage during the off-season results in the athletes being in a sub-optimal condition for competition[4)]. Another study has correlated physical characteristics with playing activity. Athletes who feel weary or less enthusiastic about exercise have less lean body mass[5)]. Sudden stop training at the end of the season promotes body fat accumulation that has been correlated with weariness[2)]. These reports suggest that training during the off-season correlates with caloric intake. The main goal of exercise for athletes during the off-season is to maintain physical strength, and this is different from the goal of training during the season[1)]. Thus, knowing the physical characteristics and physiological condition of athletes during the off-season is important for planning appropriate exercise and nutrition programs. Female athletes have additional specific problems including anemia, low bone density and unidentified clinical symptoms. So, an inappropriate reduction in body mass potentially is harmful for female athletes. On the other hand, body mass changes variously in season and female athletes are as concerned about their body image as other young women[6,7,8)]

The winter climate in the snowy regions of Japan (Hokuriku area) is too harsh to train outdoors, so athletes usually exercise using indoor facilities, and thus they might consume less energy than when exercising outdoors. Careful program planning is needed for off-season training in a harsh winter climate. We studied seasonal alterations of physical characteristics and physiological condition in nine collegiate female softball players to understand the fundamental physiological condition of female athletes in snowy area of Japan.

Materials and methods

Subjects. We enrolled nine collegiate female softball players (average age at start and end of study, 18.8 and 19.7 y, respectively) in the Hokuriku region, which is located aside the Sea of Japan and subject to very harsh, snowy winters.

Ethical considerations. The aims, methods and publication of the study were explained to the students and those who provided written, informed consent to participate were enrolled. The students were also informed that they could opt out of the study at any time if they wanted. The study and report were completed in accordance with the ethical code of Kanazawa Gakuin College (Code #47).

Study schedule. To understand the seasonal variations in physical characteristics and physiological condition, the students were recorded just after the season finished on September 5, 2011, during the off-season on December 17, 2011 and when the season started on July 14, 2012.

Study. Fundamental features of the students included age, occurrence of menstruation on the day of the exami-

* Dept. Food and Nutrition Science, Kanazawa Gakuin College, 10 Sue-machi, Kanazawa 920-1392, Japan
** Dept. Nutrition Science, Tokyo Kasei University, Clinical Nutrition Intelligence Laboratory, 1-18-1 Kaga, Itabashi-ku 173-8602, Japan

nation, medical history, and smoking habits. The height and weight of the students were measured using In Body (Biospace Co.), and physical characteristics were determined using BODPOD (LMI Co.) according to the manuals provided by the manufacturers. Values were then analyzed using the integral software.

Physical strength. Grip strength was measured, then leg strength and endurance were determined by ten repetitions of the sit-stand-sit test and a 20-m shuttle run test, respectively. These parameters were selected based on the Ministry of Education, Culture, Sports, Science and Technology of Japan's New Physical Strength Testing Guidelines.

Study of fatigue. The students responded to a questionnaire about eye fatigue, weariness, languor, and feelings of disquiet and discomfort. Each parameter comprised of five symptoms; for example, weariness was estimated based on feelings of heaviness in the arms and in the legs, lumbago, aching fingers and stiff shoulders. All of these were scored from 1 to 5, with a score of 5 describing the symptom very well. Levels of students' fatigue were represented by summing the symptom scores.

Statistical analysis. Data were analyzed using IBM SPSS Statistics 21.0 for Windows. Averages for all parameters were quantified because the distribution of the raw sample data was rather diverse. We applied the Friedman's test for statistical analysis. Statistical significance was defined using a two-sided Friedman's exact test as < 5% due to the small sample size.

Results

All students were non-smokers and one had asthma. Five students had regular 23 - 30-day menstrual cycles at the times of examination and four had irregular cycles. Table 1 shows the averaged physical and physiological parameters of the students during the studied period. Height did not change during the year and body mass remained essentially the same between September and July. However, lean body mass decreased from 43.7 to 42.4 kg between September and December and then significantly increased to 45.2kg in July ($p < 0.001$). The body fat ratio increased from 21% to 23% between September and December, indicating a body mass increase of 1.0 kg of fat within this period (11.7 to 12.7 kg; Table 1). The body fat ratio and amount decreased from 23.0% to 18.9% and from 12.7 to 10.6 kg during the next seven months and were lower in July than they had been during the previous September.

Table 1. Physical characteristics and physiological parameters of students.

		September $n = 9$		December $n = 9$		July $n = 9$		p*
Height	cm	157.7	(5.8)	157.7	(5.7)	157.8	(5.6)	0.874
Total body mass	kg	55.4	(4.3)	55.1	(4.2)	55.8	(5.3)	0.569
Lean body mass	kg	43.7	(2.8)	42.4	(3.2)	45.2	(4.3)	<0.001
Body fat	kg	11.7	(2.0)	12.7	(1.5)	10.6	(2.5)	0.019
Body fat ratio	%	21.0	(2.2)	23.0	(1.9)	18.9	(3.6)	0.003
BMI (weight / height^2)	kg/m^2	22.2	(1.4)	22.2	(1.3)	22.3	(1.3)	1.000
Systolic blood pressure (SBP)	mmHg	104	(7)	110	(12)	104	(15)	0.278
Diastolic blood pressure (DBP)	mmHg	60	(5)	60	(8)	63	(17)	0.971
Grip strength (right)	kg	30	(4)	30	(6)	29	(5)	0.154
Grip strength (left)	kg	31	(4)	29	(4)	27	(3)	<0.001
10 sit-stand-sit repetitions	seconds	8.3	(1.2)	7.9	(1.3)	7.4	(0.7)	0.069
20-m shuttle runs	times	79	(14)	83	(12)	79	(13)	0.314

Values in parentheses indicate the average and the standard deviation.
*Determined by Friedman's test.

Figure 1 shows changes in body fat ratios in each student. The body fat ratios in all students did not change between December and July, increased in seven of the nine students between September and December; it then decreased in those students over the next seven months. The decreases in the body fat ratios of six students during these seven months exceeded the increases between September and December. Two (E and I) of four students (D, E, F and I) with irregular menstruation had rather larger decreases in body fat ratio between December and July.

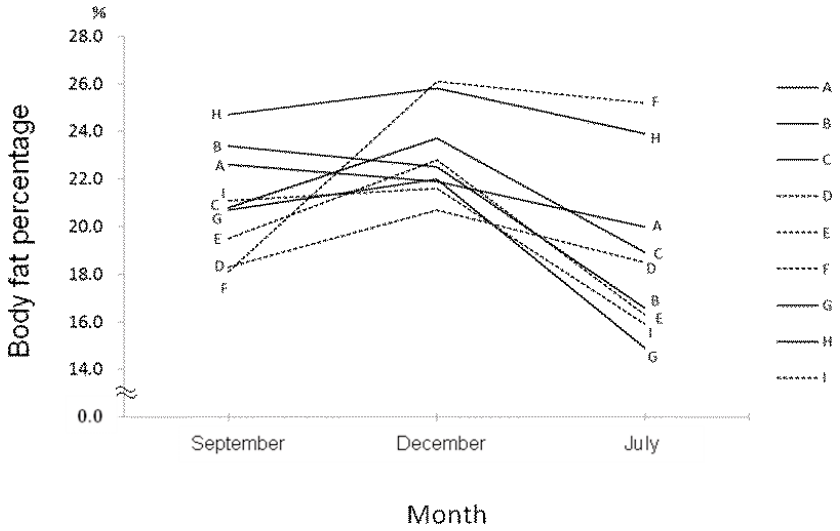

Figure 1. Changes in body fat ratios of all students.

Body fat ratio was measured and analyzed using BODPOD (LMI Co.) with integral software. A to I represent exact body fat ratios of individual female athletes at different times. Dashed lines indicate students with irregular menstruation.

The students' BMI remained unchanged throughout the year (Table 1). Systolic blood pressure (SBP) slightly increased in December, whereas changes in diastolic blood pressure (DBP) were negligible throughout the study period.

A decrease of grip strength of right hand was negligible during the study period. However, that of the left hand decreased from 31 to 29 kg during the off-season between September and December and then continued to decrease from 29 to 27 kg following the next seven months ($p < 0.001$; Table 1). The continuous decrease in strength during the off-season that reached 4 kg less at the start of the season compared with the previous post-season is important. The time required to complete ten repetitions of sit-stand-sit test improved from 8.1 to 7.5 s between September and July, but the difference was not statistically significant. The repetition times were determined in 20-m shuttle runs in which the students continuously ran between points set 20-m apart with increasing speed at intervals that were synchronized to the increasing rhythms of a recorded audio melody. Times in the 20-m shuttle run test improved somewhat between September and December and then decreased over the next seven months, but the difference did not reach statistical significance (Table 1).

Table 2. Average scores in fatigue questionnaire and summary of scores.

Points	September $n = 9$		December $n = 9$		July $n = 9$		p*
Eye fatigue	7.7	(2.1)	10.9	(5.2)	9.9	(3.8)	0.156
Bleary eyes	1.8	(1.0)	2.6	(1.1)	2.4	(1.2)	0.068
Eye strain	2.0	(1.0)	2.4	(1.1)	2.4	(1.0)	0.197
Orbital ache	1.1	(0.3)	1.8	(1.0)	1.6	(0.7)	0.037
Dry eyes	1.4	(0.5)	2.2	(1.2)	1.6	(0.7)	0.102
Dim view	1.3	(0.5)	1.9	(1.3)	1.9	(0.9)	0.407
Weariness	9.4	(3.9)	10.4	(5.4)	12.6	(5.1)	0.556
Heaviness of the arms	1.9	(1.3)	1.9	(1.2)	1.9	(0.9)	0.986
Lumbago	2.1	(1.1)	2.6	(1.3)	3.0	(1.8)	0.206
Aching fingers	1.0	(0.0)	1.4	(0.7)	1.9	(1.2)	0.115
Heaviness of the legs	2.3	(1.0)	2.0	(1.1)	2.8	(1.5)	0.699
Stiff shoulders	2.1	(1.2)	2.6	(1.7)	3.0	(1.2)	0.295
Languor	15.9	(5.3)	15.7	(5.3)	17.3	(3.7)	0.701
Disquiet	10.2	(3.3)	10.3	(3.7)	11.0	(4.7)	0.945
Feeling of discomfort	8.9	(4.6)	8.7	(4.5)	8.9	(3.5)	0.738

Values in parentheses indicate the average and the standard deviation.
*Determined by Friedman's test.

Table 2 shows the average scores of subjective fatigue symptoms and an averaged summary. Fatigue was classified into symptoms of weariness, eye fatigue, languor, and feelings of disquiet and discomfort. The students scored these symptoms on a scale of 1 to 5 (where higher scores mean more intense feelings of fatigue) in a questionnaire. Feelings of disquiet and discomfort did not seasonally vary, whereas the most languor was experienced in July than at any other point in the season, but without any statistical difference. Eye fatigue was more prevalent during December (score: 10.9) and during the following July (score: 9.9) than during the previous September (score: 7.7). Eye fatigue increased in all students between September and December. The incidence of orbital ache significantly increased in some of them during this period. Sum weariness scores tended to increase between September and December and increased more during the following July (9.4 vs.10.4 and 12.6), but the differences was not statistically different. All symptoms of weariness except heaviness in the arms tended to increase over time. Figure 2 shows summarized seasonal changes in weariness for individual students. Half students felt that weariness increased over time throughout the off-season. Four (A, H, B and I) of the nine students felt that weariness improved somewhat between December and the following July. However, the increases in individual scores between December and the following July were smaller than those between September and December. Three (F, E and D) of four (D, E, F and I) students with irregular menstruation felt more weariness between December and July. Thus, a total of five (G, F, E, D and C) students felt wearier during the off-season.

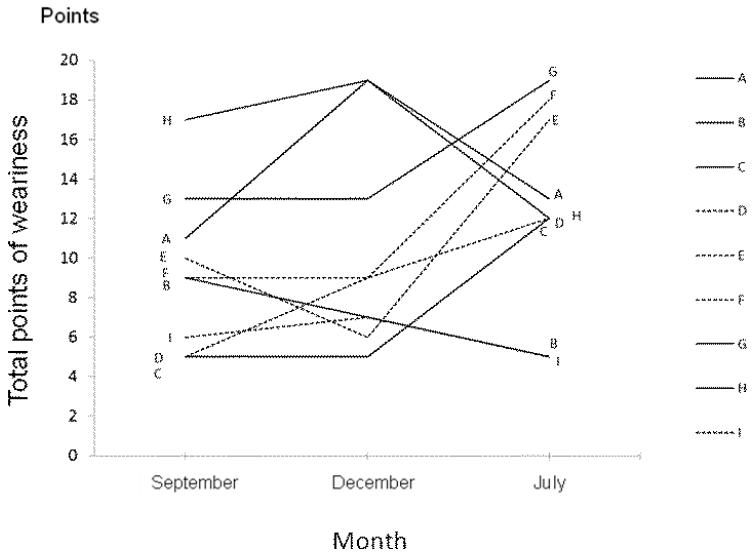

Figure 2. Summary of changes in weariness in all students.
Weariness was determined by the students' answers to a questionnaire with scores of 1 to 5 representing none to intense feelings of weariness, which were then summarized. A to I represents total weariness scores of all female athletes at different times. Dashed lines indicate students with irregular menstruation.

Discussion

Athletes should train following to specifically planed program throughout the year in order to be in peak condition for the start of the season. Many reports suggest the importance of appropriate training programs to improve their condition and maximize performance[1, 9, 10]. Physical characteristics closely correlate with the physiological condition, including weariness[4, 5]. Therefore, athletes must carefully consider their physical characteristics[1, 3]. Physical conditioning of off-season in snowy regions is considered to be challengeable because activities must depend on indoor facilities.

We determined physical characteristics and the physiological condition during the off-season of nine female Japanese collegiate softball players in a snowy region. They gained 1.0 kg (2.0%) of fat and lost 1.3 kg of lean body mass within the first three months of the off-season. This might be caused by an imbalance in energy supply and output because of the sudden pause in training[2]. However, six of seven students who gained extra fat lost more body fat than they gained during the next seven months. So, they gained 2.8 kg of lean body mass during

this period. The improvement in lean body mass indicated that the students appeared to be in good physiological condition at the start of the season. However, grip strength, a marker of muscular strength, was weaker than it was during the off-season. Weakened grip strength is a serious problem for softball players, as it indicates a decrease in physical strength. Moreover, feelings of fatigue continuously increased during the off-season. These findings suggest that training and fitness levels are inadequate between December and July. Fitness parameters in elite athletes, including cardiovascular ability and subcutaneous fat levels, should remain unchanged throughout the year[7]. On the other hand, a questionnaire study conducted at an American university found that female athletes are concerned about their body image and thus diet during the off-season[8]. This also is probably true for Japanese collegiate female athletes, as body weight can be reduced through decreasing energy intake. Since the students described herein live in an area of heavy snowfall, they might use less energy during winter training than they do when training outdoors. Many studies have found that a well-balanced diet decreases body fat and fatigue and improves physiological parameters, including oxygen saturation and heart rate[11, 12]. On the contrary, athletes without dietary control tend to feel more fatigue than those with properly balanced diets[11, 13]. Younger students did not seem concerned about nutritional programs. They might have tried to lose body fat by unnatural dieting that would decrease physical strength and result in fatigue.

Four students had irregular menstruation in July. Two of them were among the five whose body fat ratio had rather remarkably decreased, and three were among the five with increased weariness between December and July. Hormonal changes in female athletes, training and changes in body weight with fat accumulation are inter-related [14, 15], so that irregular menstruation might be a result of training under conditions of imbalanced nutrition. Thus, a sudden pause in training at the end of the season might not be optimal for maintaining the body fat ratio required for peak physiological condition. Instead, gradually reduced training coupled with a staged reduction in energy intake might be extremely important for athletes during the off-season in snowy areas. An appropriate nutritional supply is also recommended to prevent gaining excessive body fat.

Concluding remarks

Accumulation of body fat during the post-season in female collegiate athletes decreases the physiological condition by the time of the next season that starts seven months later. A sudden pause of training at the end of the season, therefore, might not be recommended for maintaining the body fat ratio because of the energy usage. So, athletes in the Hokuriku area are recommended to reduce training gradually during post- to off-season coupled with a staged decrease of energy intake. Because of the lower energy utilization in indoor training during snowy winters, they are also recommended to take a well-balanced and appropriate nutrition to prevent gaining body fat during the off-season.

References

1） B. Knoepfli., MC. Riddell., E. Ganzoni., et al.: Off seasonal and pre-seasonal assessment of circulating energy sources during prolonged running at the anaerobic threshold in competitive triathletes, *Br. J. Sports Med.*, **38**, 402（2004）

2） MJ. Ormsbee., PJ. Arciero, : Detraining increases body fat and weight and decreases VO 2 peak and metabolic rate, J. *Strength Cond. Res.*, **26**, 2087（2012）

3） EW. Moore., MS. Hickey., RF. Reiser.,: Comparison of two twelve week off-season combined training programs on entry level collegiate soccer players'—performance, *J. Strength Cond. Res.*, **19**, 791（2005）

4） 坂本静夫，菅野淳，星川佳広:アスリートの身体と体脂肪 - 体組成,食事,トレーニング量から考える，*トレーニングジャーナル*，**22**，18（2000）(in Japanese)

5） 桜井洋子，沖汐美由紀，田井美穂，他：アンケート調査による高校生競技スポーツ選手のコンディションチェック，*体力科学*，**44**（1995）(in Japanese)

6） Yamashita Shizue, Imachi Yorika, Muto Shimako：Sex and Regional Differences in Seasonal Variations of Percent Body Fat among Young Japanese Students，Kurashiki Sakuyo University, *Bulletin of Kurashiki*

Sakuyo University & Sakuyo Junior College, **38**, 51（2005）(in Japanese)
7） Koutedakis, Y.: Seasonal variation in fitness parameters in competitive athletes, *Sports Med.*, **19**, 373, Review（1995）
8） R. Selby., HM. Weinstein., TS. Bird.,: The health of university athletes: attitudes, behaviors, and stressors, *J. Am. Coll. Health*, **39**, 11（1990）
9） FR.Noyes., SD. Barber-Westin., ST. Smith., et al.: A training program to improve neuromuscular and performance indices in female high school basketball players, *J. Strength Cond. Res*., **26**, 709（2012）
10） MT. Jones., TD. Matthews., M. Murray., et al.: Psychological correlates of performance in female athletes during a 12-week off-season strength and conditioning program, *J. Strength Cond. Res*., **24**, 619（2010）
11） Ebi Kumiko, Nakao Fumiko, Uemura Kakuko, et al.：Effect of Nutrition Education on the Body Composition of High School Baseball Club Members, *THE JAPANESE JOURNAL OF NUTRITION AND DIETETICS*, **64**, 13（2006）(in Japanese)
12） Matsuda Yoshiko, Yasutake Ritsu, Ozawa Yuji, et al.: Research on the Relation between Eating Habits and Fatigue of Sports Players (1) : For “Judo” Players, *Memoirs of the Faculty of Education, Kumamoto University*, **44**, 219（1995）(in Japanese)
13） Matsuda Yoshiko, Yasutake Ritsu, Katsuki Takato：Research on the Relation between Eating Habits and Fatigue of Sports Players (3) : For Land Players, *Bulletin of Center for Educational Research and Training Faculty of Education Kumamoto University*, **16**, 41（1999）(in Japanese)
14） R. Tegelman., C. Johansson., P. Hemmingsson., et al.: Endogenous anabolic and catabolic steroid hormones in male and female athletes during off season, *Int. J. Sports Med*., **11**, 103（1990）
15） FL. Morris., WR. Payne., JD. Wark.,: Prospective decrease in progesterone concentrations in female lightweight rowers during the competition season compared with the off season: a controlled study examining weight loss and intensive exercise, *Br. J. Sports Med*., **33**, 417（1999）

北陸地域における大学生女子スポーツ選手の健康状態に関する研究

要　約

雪が多い地方の女子選手の年間健康状態を把握する研究を行った．対象は大学女子ソフトボール選手9人で，シーズン終了後の9月，シーズンオフの12月，シーズン開始の7月に，体力，疲労，月経状態を調べた．体力は，握力，椅子の座り立ち，20mシャトルランを調べた．ねむけ感，だるさ感，ぼやけ感，不安定感，不快感の5項目の疲労感について，自記式調査で回答を得た．年間を通じて体重に変化は無かったが，9月から12月に体脂肪率が増加し，7月に減少した．この間，疲労感は増加傾向を示し，シーズンオフ中の体調管理がうまくいっていないことを示した．特に，7月に体脂肪率が減少した者は月経不順者が多く，疲労感も多かった．つまり，女子ソフトボール選手の調整期に体脂肪率が緩やかに減少すれば，健康管理もうまくいくことが考えられた．