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Effect of Honeybee Products on Exercise Performance and Blood Chemistry Characteristics in Gymnasts

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Abstract

Honeybee products have recently begun to attract attention with their effects on athlete performance. In the present study, it was aimed to investigate the effects of honeybee products' mixtures on the performance and some blood biochemical parameters of young trained gymnasts. Twenty-four young gymnasts aged between 6 and 12 years were observed for 4 weeks as they continued their usual daily training schedules. The gymnasts were divided into three groups. Group 1 was administered a mixture of honey and bee pollen at a dose of 50 g/day, whereas Group 2 was provided with a mixture of honey, bee pollen, royal jelly and propolis. Group 3 served as the control group and was administered a placebo of wheat starch at a dose of 50g/day. In the beginning and at the end of the study, performance parameters and biochemical parameters of young gymnasts were determined. After treatment, grip force and muscular strength measurements increased in Group 2 ($p<0.05$). The muscular endurance tests in the two honeybee product mixtures treatment groups showed improvement after supplementation ($p<0.05$). The improvement noted in the power test in Group 1 was significantly higher than the other groups ($p<0.05$). There was no significant difference between treatment and placebo groups in all investigated biochemical parameters except total protein, which was lower in placebo group. Although bee products supplements were administered only for a short period of time, the gymnasts showed higher performance in some investigated parameters. It is recommended to conduct further long-term studies using bee products.
Keywords: Honeybee products, Young gymnasts, Performance, Biochemical parameters, Sports nutrition

Genç Cimnastikçilerde Arı Ürünlerinin Egzersiz Performansına ve Kan Kimyası Özelliklerine Etkisi

Öz

Arı ürünleri, sporcu performansı üzerindeki etkileri ile son zamanlarda dikkat çekmeye başlamıştır. Bu araştırmada, arı ürünleri karışımlarının genç cimnastikçilerde sporcu performansı ve bazı biyokimyasal parametreler üzerindeki etkileri incelenmiştir. Çalışma, yaşları 6 ve12 arasında değişen 24 genç cimnastikçi üzerinde olağan günlük antrenman programlarına devam ettikleri 4 hafta boyunca yürütülmüştür. Cimnastikçiler üç gruba ayrılarak 1. Gruba 50 gr/gün bal ve arı poleni karışımı, 2. Gruba bal, arı poleni, arı sütü ve propolis karışımı verilmiştir. 3. Grup kontrol grubu olarak alınmış ve 50g/gün dozunda buğday nişastası placebo olarak verilmiştir. Çalışmanın başında ve sonunda genç cimnastikçilerin performans ve biyokimyasal parametreleri değerlendirilmiştir. Uygulama sonrasında sporcuların kavrama kuvveti ve kas kuvveti ölçümleri 2. Grupta artış göstermiştir ($p<0.05$). İki arı ürünü karışımı alan 1. Grupta ise kas dayanıklılık testleri iyileşme göstermiştir ($p<0.05$). 3. Grupta daha düşük olan serum toplam protein değeri dışında, incelenen diğer tüm biyokimyasal parametrelerde gruplar arasında önemli bir fark görülmemiştir. Cimnastikçiler arı ürünleri desteğini kısa bir süre için kullanmalarına ragmen daha yüksek performans göstermişlerdir. Arı ürünlerinin daha uzun süreli kullanıldığı çalışmaların yapılması önerilmektedir.
Anahtar kelimeler: Arı ürünleri, Genç cimnastikçiler, Performans, Biyokimyasal parametreler, Sporcu beslenmesi

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INTRODUCTION

Gymnastics, a sport branch that is exciting, admirable to watch with its artistic taste, has been very popular in recent years. Starting this sport early in life contributes to cognitive, effective and psychomotor development as well as healthy body development, and improves performance. Gymnastics requires strength, flexibility, agility, and coordination that enable all muscles to work using the body's natural movements (Jemni et al., 2006; Sands et al., 2002). With these features, gymnastics requires intense energy expenditure. Also, the increasing energy and nutritional needs of children and adolescent athletes during the period of rapid growth and development must be fully met.

This energy intake includes a high carbohydrate diet as well as protein and nutrient-rich foods to provide the raw materials for building and maintaining muscle tissue. Therefore, children and young athletes must develop good nutritional habits and maintain a diet containing sufficient amounts of energy and nutritious food. The ideal diet for all gymnasts should be high in carbohydrates, moderate in protein and low in fats, and should contain adequate amounts of vitamins, minerals and micronutrients (Artık, 2019; NCAA, 2018).

Honeybee products have recently begun to attract attention with their health effects and rich content because of their effects on athlete performance. Honey is a natural sweet substance produced by *Apis mellifera* bees from the nectar of plants or secretions of living parts of plants or excretions of plant-sucking insects onto the living parts of plants, which the bees collect, transform by combining with specific substances of their own, deposit, dehydrate, store and leave in honeycombs to ripen and mature (EU, 2002). Chemically, honey contains sugar (80%), water (15–20%) and minor compounds (1-2.6%) such as organic acids, minerals, proteins, phenolic compounds and amino acids (Bogdanov, 2016).

Royal jelly is a honeybee secretion used for feeding larvae as well as adult queens. It is secreted from glands in the hypopharynx of worker bees. The composition of royal jelly, in terms of proteins, carbohydrates and lipids, is reported in the literature (Sabatini et al., 2009). Chemically fresh royal jelly contains water (60-70%), proteins (9-18%), carbohydrates (5-15%), lipids (3-8%), mineral salts (1.5%) and vitamins together with a large number of bioactive substances (Ramadan and Al-Ghamdi, 2012). Additionally, royal jelly has a positive effect on the athlete's body and can be used for medical purposes ranging from pediatrics to geriatrics. It has been demonstrated that royal jelly has several physiological effects such as the improvement of heart function, strengthening and increasing the body's resistance, regulation of adrenal gland function under stress, depression, relief, fatigue, nervousness, insomnia, stimulation of endocrine glands and regulation of functioning of all organs and tissues, etc. (Joksimović et al., 2009). Additionally, Park et al., (2009) demonstrated that the administration of royal jelly protein in exercise-trained rats increases the muscle oxidative capacity and improves endurance in exercise performance.

Propolis, another honeybee product, is a resinous substance that bees collect from the exudates of plants, which they use to seal holes in the beehive. It is mainly composed of resin (50%), wax (30%), essential oils (10%), pollen (5%) and other organic compounds (5%). Propolis contains more than 300 components including phenolic aldehydes, polyphenols, sequiterpene

quinines, coumarins, steroids, amino acids and inorganic compounds (Khalil, 2006). It has been shown that propolis has pharmacological properties such as antibacterial, antiviral, antifungal, antioxidant, anti-inflammatory, immunostimulating as well as cytostatic activity (Marcucci, 1995).

Bee pollen is mainly the male gametophyte of flowers collected by *Apis mellifera* to feed its larvae in the early stages of development. Bee pollen is composed of proteins, lipids, sugars, fiber, mineral salts, amino acids, phenolic compounds and vitamins. Pollen composition is very variable depending on the floral origin. The average commercially traded dried bee pollen composition is said to be not less than 40% carbohydrates, 15% proteins, 3% minerals and vitamins and 1.5% fat (Campos et al., 2008). Pollen is also rich in flavonoid and phenolic compounds. Their antioxidant effects are related mainly to their free radical scavenging activities. Bee pollen is accepted as an optimal food for athletes. In some countries, bee pollen preparations or extracts have been used by competitive athletes as a dietary supplement (Kostic et al., 2020).

It is thought that this rich and unique content of bee products will be effective in meeting the special energy and nutrient requirements of athletes. The effects of bee products, especially honey, on different sports branches have been investigated in various studies (Safitri et al., 2020). However, the effect of honeybee products mixture on young gymnasts, which are important for their energy and nutrient requirements, has not been studied sufficiently. Therefore, the main aim of this study was to determine the effects of honeybee products' mixtures on the performance and blood chemistry characteristics of young trained gymnasts.

METHODS

Research Model

This study examined the effects of honeybee products' mixtures on the performance and blood chemistry characteristics of young trained gymnasts. For this reason, the study adopted a relational screening model, one of the quantitative research designs. In this study, the research design consists of the pre-test and post-test experimental designs, and they are matched paired control group design. Experimental design is the research area in which the data to be observed are produced to discover the cause-effect relationships between the variables under the researcher's control.

Population and Sample

A total of 24 healthy gymnasts, an equal number of females and males, aged between 6 and 12 years old were included in the study. Volunteer athletes were selected from Gym Club in Kayseri, Turkey. Gymnasts were divided into three groups consisting of 8 athletes, according to given different honeybee product for 4 weeks and each group. They have performed the same usual daily training program. The workouts were mostly composed of strength exercises and continued for two hours. The effects of athletes given different mixtures on performance

and biochemical parameters were compared. The botanical origin of honey and pollen used in the study was Chestnut (*Castanea sativa*) and the geographic origin was Yalova, Turkey. Royal jelly and propolis were obtained from Nutral Therapy Company (Erciyes University Science and Technology Park, Kayseri). The athletes in Group 1 and Group 2 received two different mixtures of bee products (50g) and the placebo group received wheat starch (50g). The ingredients of the mixtures were as the follows: Group1, bee product mixture contained 95% honey, 5% bee pollen. Group 2, bee product mixture contained 84.25% honey, 10% bee pollen, 5% royal jelly and 0.75 % propolis. The dose was selected according to references (Yosef and Shalaby, 2010). Mixtures and starch were consumed 25-30 min before breakfast once a day for 4 weeks. The supplements did not contain food items other than the bee products. During the study, the athletes were instructed not to consume other bee products and maintain a standard diet.

Ethical Approval

Athletes and also their parents were informed about research and practice, and the "Enlightened Written Consent Form" was received from the athletes and their families. The study was approved by the Ethics Committee of Erciyes University in Kayseri (2012-403). This study was carried out following the latest version of the Helsinki Declaration. The data associated with the paper are not publicly available but are available from the corresponding author on reasonable request.

Data Collection

Blood samples were collected from the athletes in the beginning and at end of the study. After an overnight (12 h) fasting, blood glucose, total cholesterol, total protein, creatinine, BUN, Ca, P, Na, K, Cl, AST, ALT and ALP levels were measured. Biochemical analyses were performed at the Central Laboratory of the Hospital of Gevher Nesibe Medical School at Erciyes University. An Architect C800 Auto analyzer (Abbott, Istanbul, Turkey) was used (ISE speed 400 tests/hour) for spectrophotometric analysis. Anthropometric measurements (body weight, height, BMI, and body fat mass) of the athletes were performed before and after the study by bioelectrical impedance, Tanita 418 MA. Attention was paid to privacy during taking anthropometric measurements of children, and measurements were made in a private room with two researchers. Among performance parameters, pull-ups, sit-ups, flexibility, agility, speed and power characteristics were measured in the beginning of the study and after 4 weeks to assess whether there was a change in values within all of the research groups as well as possible differences between experimental and placebo groups. All the tests were repeated three times and three measurements were averaged.

Data Analysis

Statistical analyses were performed using the SPSS software version 15. Descriptive analyses were presented using means and standard error of the means. Changes in pre-training and post-training variables within the same group were tested by dependent samples Paired Student's t-test. One-way Anavo analysis of variance was used to determine the statistically significant differences between the groups. When an overall significance was observed, pairwise post-hoc test were performed using LSD test. A p-value of less than 0.05 was considered to show a statistically significant result.

RESULTS

Table 1. Anthropometric variables of gymnasts

Variables	Group1 (n=8) M±SEM	Group 2 (n=8) M±SEM	Placebo (n=8) M±SEM	*p*
Age (years)	7.75±0.70	7.75±0.59	7.13±0.44	*0.690*
Height (cm)	130.00±2.83	128.38±4.12	125.63±2.83	*0.647*
Body Weight (kg)	26.89±2.46	26.80±2.57	24.90±1.58	*0.781*
BMI (kg/m^2)	15.69±0.77	15.94±0.51	15.66±0.43	*0.936*
BMR	1102.50±41.18	1089.88±56.13	1089.25±38.79	*0.974*
Body Fat (%)	16.48±1.24	18.09±1.22	17.18±1.27	*0.659*
Fat Mass (kg)	4.51±0.68	4.88±0.61	4.29±0.41	*0.771*
FreeFat Mass (kg)	22.38±1.89	21.91±2.07	20.63±1.36	*0.778*
Total Body Water (kg)	16.39±1.39	16.04±1.52	15.10±0.99	*0.777*

p<0.05; SEM: Standard Error of the Mean; Group1: 50 g (honey+ bee pollen+royal jelly +propolis); Group2: 50 g (honey + bee pollen+royal jelly); Placebo: 50 g wheat starch

Anthropometric measurements of the gymnasts are presented in Table 1. There was no statistically significant difference in anthropometric measurements between the groups (p>0.05).

Table 2. Performance parameters of gymnasts between pre and post test.

Variables		Group 1 (n=8) M±SEM	Group 2 (n=8) M±SEM	Placebo (n=8) M±SEM	p
Right Hand Grip Strength (kg)	Pre-test	13.00±1.49	12.38±1.66	10.63±1.48	*0.602*
	Post-test	13.38±1.46	13.71±2.07	11.38±1.51	*0.448*
	p	*0.257*	*0.236*	*0.165*	
Left Hand Grip Strength (kg)	Pre-test	12.50±1.81	11.75±1.56	11.00±1.49	*0.819*
	Post-test	12.75±1.63	12.71±2.00	11.50±1.68	*0.775*
	p	*0.577*	*0.408*	*0.336*	
Pull-up Test (Repeat)	Pre-test	6.25±2.14	7.38±1.85	5.75±2.18	*0.69*
	Post-test	6.38±2.12	8.50±2.17	6.63±2.56	*0.703*
	p	*0.655*	***0.04***	*0.059*	
Sit-ups Test (Repeat)	Pre-test	41.75±2.81	39.63±2.32	40.50±2.63	*0.862*
	Post-test	45.38±3.73	45.00±2.97	43.25±3.49	*0.906*
	p	***0.017***	***0.018***	*0.223*	
Flexibility Test (cm)	Pre-test	17.50±1.13	18.25±1.64	14.75±1.36	*0.159*
	Post-test	18.13±1.14	19.25±1.63	16.13±1.55	*0.289*
	p	*0.096*	*0.197*	***0.038***	
Agility Test (20 second)	Pre-test	4.48±0.23	4.61±0.39	4.09±0.33	*0.366*
	Post-test	4.43±0.23	4.58±0.38	4.06±0.33	*0.366*
	p	*1*	*1*	*1*	
Speed Test (50 Yard)	Pre-test	8.80±0.49	9.03±0.45	9.26±0.47	*0.768*
	Post-test	8.71±0.47	8.93±0.43	9.21±0.47	*0.768*
	p	*1*	*1*	*1*	
Power Test (long jump) (cm)	Pre-test	158.88±8.77	151.25±8.81	147.13±6.90	*0.586*
	Post-test	161.25±8.60	152.63±8.69	148.63±6.97	*0.584*
	p	***0.016***	***0.016***	***0.026***	

p<0.05; SEM: Standard Error of the Mean; Group1: 50 g (honey+ bee pollen+royal jelly +propolis) Group2: 50 g (honey + bee pollen+royal jelly); Placebo: 50 g wheat starch

Concerning grip force and muscular strength measurements of the athletes, there was no significant difference between groups whereas, the increases in both parameters in honey+bee pollen+royal jelly+propolis treated group after treatment (Group 2) were statistically significant ($p<0.05$). The muscular endurance tests in the two treatment groups showed improvement after supplementation as compared to the values before the administration of the supplements ($p<0.05$). No significant difference was determined between groups for the flexibility test but it showed slight but not significant improvements in all three groups. No differences were determined in agility and speed tests. Power test showed improvement in the three groups, and the differences from the baseline values were found to be statistically significant ($p<0.05$, $p<0.01$, and $p<0.001$). The improvement noted in the power test in Group 1 was significantly higher than the other groups ($p<0.05$) (Table 2).

Table 3. Hemogram of gymnasts between pre and post test

Variables		Group 1 (n=8) M±SEM	Group 2 (n=8) M±SEM	Placebo (n=8) M±SEM	p
Erythrocyte Subgroups					
RBC (10^6 /mL)	Pre-test	4,81±0.10	4.76±0.14	4.88±0.08	*0.481*
	Post-test	4,69±0.10	4.73±0.1	4.77±0.05	*0.662*
	p	***0.183***	*0.833*	*0.208*	
Hgb (g/dL)	Pre-test	13.52±0.44	12.86±0.32	13.42±0.22	*0.180*
	Post-test	13.12±0.42	13.07±0.24	13.31±0.23	*0.709*
	p	***0.024***	*0.325*	***0.526***	
Hct (%)	Pre-test	39.613±1.22	39.63±1	40.26±0.63	*0.386*
	Post-test	38.05±0.92	38.01±0.6	39.23±0.64	*0.356*
	p	***0.042***	*0.092*	*0.123*	
MCV (fL)	Pre-test	82.3±1.81	82.67±1.24	82.48±1.03	*0.746*
	Post-test	81.14±1.71	80.51±1.09	82.15±0.9	*0.544*
	p	***0.05***	***0.012***	*0.575*	
MCH (pg)	Pre-test	28.1±0.68	27.01±0.32	27.51±0.42	*0.083*
	Post-test	27.99±0.79	27.7±0.52	27.93±0.43	*0.661*
	p	*0.575*	*0.107*	*0.262*	
RDW (%)	Pre-test	13.57±0.39	14.01±0.34	13.47±0.36	*0.369*
	Post-test	13.6±0.36	13.68±0.28	13.42±0.25	*0.695*
	p	*0.553*	*0.051*	*0.733*	
Leukocyte Subgroups					
WBC(10^ 3/µL)	Pre-test	6.04±0.49	8.67±0.7	7.35±0.51	*0.022*
	Post-test	6.83±0.67	8.35±0.95	7.08±0.49	*0.269*
	p	***0.012***	*0.779*	*0.575*	
NE (%)	Pre-test	48.72±2.31	55.82±4.06	50.5±1.94	*0.424*
	Post-test	46.86±2.8	54.48±3.99	51.16±2.51	0.482
	p	*0.401*	*0.575*	*0.401*	
LY (%)	Pre-test	40.96±2.12	33.52±3.73	38.32±1.7	*0.225*
	Post-test	40.61±2.51	33.6±3.42	38.17±2.6	*0.286*
	p	*0.069*	*1*	*0.779*	
MO (%)	Pre-test	5.05±0.18	*5.43*±0.49	5.26±0.41	*0.945*
	Post-test	4.98±0.32	*5.12*±0.6	5.17±0.41	*0.888*
	p	*0.182*	*0.889*	*0.833*	
EO (%)	Pre-test	1.5±0.28	2.31±0.57	2.57±0.56	*0.382*
	Post-test	3.17±0.4	2.87±0.9	1.8±.24	***0.05***
	p	***0.017***	*0.528*	*0.233*	
BA (%)	Pre-test	0.58±0.13	0.5±0.11	0.67±0.15	*0.604*
	Post-test	0.58±0.08	0.3±0.06	0.52±0.06	***0.027***
	p	*0.61*	*0.14*	*0.344*	
Platelet Subgroups					
PLT (10^ 3/µL)	Pre-test	342.37±24.97	393.25±20.21	388.12±29.38	*0.255*
	Post-test	331.37±26.21	349.87±25.03	391.12±42.62	*0.482*
	p	*0.674*	***0.05***	***0.944***	
MPV (fL)	Pre-test	8.7±0.32	8.06±0.36	8±0.28	*0.120*
	Post-test	7.03±0.17	6.92±0.17	7.45±0.41	*0.734*
	p	***0.017***	***0.017***	***0.208***	

p<0.05; SEM: Standard Error of the Mean; Group1: 50 g (honey+ bee pollen+royal jelly +propolis) Group2: 50 g (honey + bee pollen+royal jelly); Placebo: 50 g wheat starch

In Group 1, significant decreases were observed in Hbg, Hct and WBC levels. The MCV levels were decreased in both treatment groups whereas RDW level decreased in only in Group 2 when compared to pre-treatment level (Table 3).

Table 4. Biochemical parameters of gymnasts between pre and post test

Variables		Group1 (n=8) M±SEM	Group2 (n=8) M±SEM	Placebo (n=8) M±SEM	*p*
Glucose (mg/dL)	Pre-test	95.13±2.72	88.50±3.85	91.13±2.64	*0.338*
	Post-test	90.13±2.59	87.63±2.38	84.88±2.05	*0.305*
	p	*0.068*	*0.67*	***0.018***	
Triglyceride (mg/dL)	Pre-test	57.13±6.30	61.38±5.12	59.13±6.91	*0.588*
	Post-test	65.25±8.10	76.25±13.75	64.88±9.81	*0.697*
	p	*0.161*	*0.779*	*0.310*	
Total cholesterol (mg/dL)	Pre-test	156.75±8.88	165.13±5.93	158.50±8.52	*0.620*
	Post-test	160.50±10.09	176.38±6.02	170.63±12.38	*0.484*
	p	*0.575*	*0.107*	*0.068*	
BUN (mg/dL)	Pre-test	11.25±0.77	11.00±0.85	11.75±1.29	*0.952*
	Post-test	11.13±0.77	10.50±0.65	9.13±0.67	*0.143*
	p	*0.892*	*0.157*	***0.035***	
Creatinine (mg/dL)	Pre-test	0.55±0.03	0.56±0.03	0.55±0.03	*0.921*
	Post-test	0.55±0.02	0.56±0.02	0.55±0.03	*0.954*
	p	*1*	*0.528*	*0.245*	
Calcium (mg/dL)	Pre-test	9.89±0.08	9.88±0.16	10.08±0.13	*0.502*
	Post-test	9.59±0.11	9.71±0.17	9.73±0.08	*0.495*
	p	***0.041***	*0.307*	***0.024***	
Phosphorus (mg/dL)	Pre-test	4.63±0.20	4.78±0.16	4.76±0.17	*0.822*
	Post-test	4.83±0.20	4.83±0.20	4.93±0.10	*0.959*
	p	*0.207*	*0.799*	*0.235*	
Sodium (mmol/L)	Pre-test	138.00±0.33	138.50±0.85	137.38±0.73	*0.368*
	Post-test	139.13±0.52	138.38±0.32	139.13±0.40	*0.374*
	p	*0.071*	*0.798*	*0.119*	
Potassium (mmol/L)	Pre-test	4.11±0.05	4.39±0.16	4.06±0.07	*0.412*
	Post-test	4.36±0.10	4.41±0.22	4.35±0.11	*0.827*
	p	***0.026***	*0.892*	***0.024***	
Chlorine (mmol/L)	Pre-test	106.88±0.77	106.50±0.60	106.63±0.75	*0.917*
	Post-test	105.88±0.44	105.50±0.57	106.63±0.56	*0.424*
	p	*0.230*	*0.071*	*0.932*	
CPK (u/L)	Pre-test	144.50±24.63	121.50±8.85	126.88±20.38	*0.927*
	Post-test	225.63±86.03	173.75±42.52	128.75±17.59	*0.811*
	p	*0.575*	*0.612*	*0.889*	
AST (u/L)	Pre-test	25.88±1.91	26.50±1.28	26.75±1.08	*0.968*
	Post-test	28.38±1.21	29.50±1.30	26.75±1.19	*0.379*
	p	*0.121*	*0.104*	*1*	
ALT (u/L)	Pre-test	19.13±1.55	15.88±0.77	18.88±1.65	*0.214*
	Post-test	16.63±1.56	16.88±1.67	20.38±2.46	*0.651*
	p	*0.112*	*0.399*	*0.892*	
ALP (u/lt)	Pre-test	231.63±24.38	199.38±11.64	234.75±16.04	*0.294*
	Post-test	243.63±21.66	203.13±16.23	227.38±10.90	*0.283*
	p	*0.260*	*0.735*	*0.574*	
Total protein (g/dL)	Pre-test	7.06±0.13	7.33±0.19	7.09±0.05	*0.442*
	Post-test	7.10±0.10	7.08±0.14	6.68±0.06	***0.003***
	p	*0.686*	*0.206*	***0.011***	

p<0.05; SEM: Standard Error of the Mean; Group1: 50 g (honey+ bee pollen+royal jelly +propolis); Group2: 50 g (honey + bee pollen+royal jelly); Placebo: 50 g wheat starch

In terms of biochemical parameters, there was no significant difference between treatment and placebo groups in all investigated biochemical parameters except total protein, which was lower in placebo group. Compared to pre-test levels, slight but not significant decreases were determined in glucose levels in both treatment groups. But in placebo group, glucose and BUN levels decreased significantly (p>0.05). In Group 1 and placebo, decreases in Calcium and the

increases in Potassium levels were statistically significant. The lower total protein level in the placebo group were found to be statistically significant ($p>0.05$) (Table 4).

DISCUSSION

Two different bee product mixtures were used in this study. The first mixture contained honey and pollen, while the second mixture contained honey along with pollen, royal jelly and propolis. The reason for using these two different mixtures was to see the effect of compound groups with important biological activities such as protein, vitamin-mineral, fatty acids, phenolic compounds as well as energy needs in gymnasts. Because honey, with its high carbohydrate content, contributes to the energy need, while pollen and royal jelly with its protein, vitamin-mineral, fatty acids, etc. content and propolis with its high phenolic compound content, it has been tested whether it will contribute to the performance of gymnasts. As a matter of fact, it was possible to see that the effect differed when we increased the amount of pollen and added royal jelly and propolis to the mixture. Actually, it was possible to see this effect in the strength test in Group 1 and in the grip force and muscular strength measurements in Group 2. Apart from this, the biochemical values of the athletes given bee products were not adversely affected.

There are several supplements and sport foods that were claimed to increase endurance, enhance recovery, reduce body fat, increase muscle mass, minimize the risk of illness or achieve other goals that enhance sports performance. Particular attention must be paid to the consumption of sufficient amount of carbohydrates while performing endurance exercises for short or long periods. The depletion of muscle glycogen places the athletes in a difficult position, and fatigue and muscle cramps result in a pause in physical activity. Murray and Rosenbloom (2018) have reported that replenishment of glycogen stores in muscle and liver as rapidly as possible for the body to be prepared for subsequent training and competition is essential. It is a well-known fact that a carbohydrate-rich diet consumed immediately before a competition makes little contribution to meet energy demands on competition day. Therefore, several previous studies have been conducted to investigate the effects of various food items with or without supplements on performance and blood chemistry in human with slight or excessive physical activity (National Institutes of Health, 2017; Peeling at al, 2018).

Honey, the main component of the supplement used in the present study, has been a very important food throughout history due to its nutritional value, taste and unique aroma. It has also been used in the treatment of certain ailments and as an ingredient in certain preparations (Eraslan et al., 2010; Koç et al., 2009). Yusof et al., (2018) has reported that honey is an excellent source of energy for athletes due to its high carbohydrate content and functional properties[23]. As claimed by other authors, honey is well tolerated and an effective carbohydrate source for athletic performance (Tikhonov et al., 2006; Turner et al., 2006; Traidl et al., 2003). Unlike carbohydrates and fats, proteins are not basic and efficient energy sources. Thus, athletes must consume sufficient amount of proteins in their diet. The bee pollen used as a supplement in the present study is known to be rich in B-group vitamins in addition to its protein and amino acid-rich content. Abramov et al., (1993) reported that the immune response, measured by the reactivity of T lymphocytes in sportsmen, returned to normal after intake of

pollen for two months. In one of the experiments with sportsmen in Russia, reviewed by Asafova et al., (2001), it was concluded that pollen can be used for recovery after periods of physical exertion. The influence of pollen intake was tested on the performance of military training in Russia and pollen could be used successfully for recovery after periods of physical strain and also improves physico-vegetative condition. Nechaeva (2009) tested the intake of 10 g pollen twice a day for 15 days on the performance of Russian female sport students. They found a significant improvement in the body's reaction to hypoxia and an improvement in viso-motor reactions. However, in some studies no positive effect was obtained from the use of pollen in swimmers and long distance runners (Maughan and Evans, 1982, Wodhouse et al., 1987).

Protein-rich royal jelly, another component of the supplements in this study. Among relevant studies that have been conducted in football players, Jaskimovic et al., (2009) reported that royal jelly caused an increase in height and muscle mass and a decrease of fat levels in post-training measurement compared with pre-training levels. Furthermore, many researchers have obtained similar results in football players and royal jelly stimulates the growth and development of the body (Bonomi, 1983). Park et al., (2009) have reported that royal jelly protein administration in exercise-trained rats resulted in increased muscle oxidative capacity and promoted an improvement in endurance exercise performance. Yıldız and Umudum (2000) have reported that administration of royal jelly for a period of one month, decreased serum cholesterol and triglyceride levels in humans aged 35-50 years. There have been a limited number of studies carried out on the individual effects of propolis on performance and biochemical parameters in athletes. Among the few indirect relevant studies many researchers have reported positive effects of propolis on biochemical parameters in rats (Eraslan et al., 2008, Kanbur et al., 2009).

The most common problem associated with nutrition in children and young athletes is satisfying energy demand. The energy requirement depends on age and growth stage and the type, duration, and intensity of exercise. Children aged between 7-10 years who engage in very intensive physical activity and competitions require 3000-3500 kcal/day, and adolescents require 4000-5000 kcal per day. It is a basic principle of nutrition in athletes that they should consume a carbohydrate-rich diet at every meal to supply the fuel needed for muscles. In recent years the market has been offering thousands of remedies that help young athletes. Their content and quality vary from common water to hormonal remedies and may generally cause substantial damage to the body. The purpose of the present study was to evaluate the ergogenic potential of two different formulations of honeybee products compared to a wheat starch-based placebo. In the present study, the administration of these nutrient-rich and complementary products to the athletes aged between 6 to and 12 years for one month improved the muscular endurance tests in the two treatment groups and strength and power tests in the Group 2 after supplementation as compared to the values before the administration of the supplements ($p<0.05$). These results confirm the findings of previous studies those investigated the ergogenic potential of honey (Wong, 2020).

Suh et al., (2007) have reported that athletes taking honey-based preparations are able to maintain blood glucose levels. Ahmad et al., (2015), have indicated that rehydration with honey

drink improves running performance and glucose metabolism compared to plain water in the heat. Maleki et al. (2016), indicated that honey is able to modulate exercise-induced peroxidative, antioxidative, and immunological changes in male road cyclists following chronic low-to-intensive exercise training and reported to be used as an anti-inflammatory and antioxidant supplement for competing athletes who participate in long-term moderate-to-intensive exercise training protocols. Kreider et al., (2002), have indicated that ingesting dextrose and honey gels during endurance cycling can improve performance, presumably by enhancing carbohydrate availability and work output. It was stated that honey significantly increases heart frequency and the blood glucose levels during a performance, and does not promote physical or physiological signs of hypoglycemia in fasting athletes (Leutholz and Kreider, 2002). In another study, Tikhonov et al., (2006) reported that honey did not promote physical or psychological signs of hypoglycemia in fasting athletes, or during resistance training. Also, in the same study, the effects of low and high glycemic index (GI) carbohydrate gels and honey were tested on a 64 km cycling performance. They have stated both high (glucose) and low GI (honey) gels increased cycling performance and the effect of honey was slightly better than the one of glucose. As claimed by other researchers (Traidl-Hoffmann et al., 2003; Turner et al., 2006), honey is well tolerated and can be an effective carbohydrate source for athletic performance. Suh et al., (2007) reported that honey-based preparations were able to maintain blood glucose levels during the trials. Again, Erejuwa (2012) stated that due to the relatively high fructose content in honey and the relatively slow rate of intestinal absorption of fructose, a slower blood glucose response following ingestion might have been expected. Yosef and Shalaby (2010) have reported that honey and water reduced the skin temperature and enhanced the glucose in the blood due to its fat absorption and its moderating effect on blood glucose in wrestlers. However, in the present study, there were no significant differences between treatments and placebo groups regarding the biochemical parameters but when pre and post treatment levels were considered, slight but not significant declines were occurred in glucose levels in both treatment groups. But the decreases in glucose and BUN levels in placebo group were significant ($p<0.05$). (Table 3). Also, compare to the treatment groups, a significant decrease was observed in the total protein levels of the placebo groups (between pre and post-treatments). Compare to the pre and post measurements, significant increases were determined in the potassium levels of Group1 and the placebo group (Figure 4). The increase in potassium level may be due to the high potassium content of honey and pollen. Moreover, calciyum levels decreased in all of the groups without any significant difference. Similar to the results of the present study, Sarıtaş et al., (2011) reported that supplementation of royal jelly during a 30-day exercise program was not significantly effective for swimmers. Also, they have reported that different doses of royal jelly were not effective on certain biochemical parameters (glucose, total cholesterol, HDL, LDL, CK levels and LDH, AST, and ALT activities) of the swimmers, whereas BUN levels were higher in a royal jelly group than others. According to these and findings of other studies, honey is well tolerated and can be an effective source of carbohydrates for athletic performance (Yosef and Shalaby 2010).

In the present study, the lack of a significant difference between the groups which were administered honeybee product mixtures and the placebo group, particularly in respect to biochemical parameters, may be related to the administration dose and duration. However, the treatments have positive effects on some performance parameters as pull-ups, sit-ups and

power. Honey, bee pollen, royal jelly and propolis are combined in different proportions, and they are marketed as different products due to their rich content. These mixtures have been widely propagated as nutritional supplements and for the prevention and treatment of different diseases such as infectious diseases, inflammatory disorders, immune and gastrointestinal ailments (Bogdanov, 2016). In the present study, the young gymnasts were treated with 50 g of mixtures of honeybee products per day. It is necessary to perform hematological and biochemical tests when giving any food supplement to the athletes. It is known that bee products have beneficial effects on health. However, in this study, a remarkable improvement was not expected since our athletes did not have any health problems. In addition, the absence of a negative effect is the findings supporting the research.

Conclusions

In conclusion, used mixtures of honeybee products had no significant adverse effect on the biochemical characteristics of young gymnasts. Although no negative effects are expected regarding the consumption of bee products, it is important to preserve the biochemical values of the athletes. It was determined that the application of 50 g honeybee product mixture to gymnasts for 4 weeks had a positive effect on some performance parameters. However, it is clear that these mixtures should be applied for a longer period of time and regularly in order for this effect to be observed more clearly. For this reason, it would be beneficial to practice with more athletes and for a longer period of time.

Conflict of Interests: The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' Contribution: Study design; NS, SB –Data collection; NS, HA –Statistical analysis; MS –Manuscript Preparation; MS, NS

Ethical Approval

Committee: Erciyes University, Scientific Research Ethic Committee

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