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INFLUENCE OF NUTRITION AND GENETICS ON PERFORMANCE: A PILOT STUDY IN A GROUP OF GYMNASTS

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ABSTRACT
Purpose. Energy requirements in sports performance are affected by numerous factors: physical characteristics, age, genetic basis, sports discipline. The Food and Nutrition Board recommended nutrition based on age, height, and body weight gain in relation to physical activity. Some genetic factors, such as the PPAR-encoding gene, play a key role in metabolism. The aim of the study was to investigate the effect of specific snacks on performance.
Methods. Seventeen girls aged 10–14 years practising artistic gymnastics were enrolled. A carb or protein/carb snack was provided before the training, and a questionnaire was administered at the end. In addition, saliva samples were collected for genetic analyses.
Results. Most girls represented the CC genotype (65%), while a small part had the GC (23%) and GG (12%). The average BMI equalled 20.05 ± 2.8 kg/m^2 in the group with the CC genotype, 19.6 ± 2.8 kg/m^2 with the GC genotype, and 20.2 ± 2.8 kg/m^2 with the GG genotype. The questionnaire showed that 59% of girls experienced a performance improvement after eating a carb snack; slightly different results were observed after the intake of a protein/carb snack: 47% felt more energy and 12% more fatigue.
Conclusions. This is a preliminary study that should be deepened by increasing the number of subjects, as well as diversifying the type of snacks administered and increasing the time of the study. It is important to be mindful of eating habits and lifestyle in order to prevent the onset of overweight.
Key words: genetics, performance, nutrition, gymnasts

Introduction

Sports performance requires different energy intake for different subjects, depending on physical characteristics, genetic basis, disciplines practiced, and age. Particular attention should be paid to adolescent athletes because their energy requirements are different from those in adults, especially during physical activity.

Usually the Food and Nutrition Board recommended nutrition based on age, height, and body weight gain of an individual in relation to lifestyle (sedentary, moderately active, active). For children aged 9–13 years, energy requirements are around 1415 kcal/day in a sedentary subject, while in the case of an active person they rise to 3038 kcal/day. In turn, for teenagers between 14 and 18 years of age, the energy demand is equal to 1718 kcal/day with sedentary and 3804 kcal/day with very active subjects [1].

The energy comes from different classes of nutrients. The most important class among the macromolecules are carbohydrates; in fact, they are considered as fuel for maintaining activity at a prolonged or repeated high intensity [2]. In children, however, the glycolytic capacity is not fully present [3]; therefore, the role of carbohydrates in performance supporting is carried out by lipids. Given the importance of carbohydrates as a high intensity substrate, it is advisable that 50% of the nutrients taken by young athletes are carbohydrates. In relation to lipids, there are no reference levels of intake, unlike for essential fatty acids (linoleic acid and linolenic acid): those change depending on the sex and age of the individual [4]. For example, the level is around 10–12 g/day for children and girls between 9 and 13 years of age. In general, one should consider that it is recommended that 25–30% of total daily calories come from fat: most of them must be unsaturated fatty acids; saturated fatty acids constitute only 10% [5, 6].

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Sufficient protein intake is important for the development and maintenance of lean mass [7]. Protein can be used as an energy substrate when carbohydrates and lipids are depleted especially in high-intensity sports [8].

It is generally recommended that both adults and teenagers get at least 12–15% of the required energy by protein intake [9].

There are several factors that affect metabolism; among these, genetic factors play a key role. The gene encoding for peroxisome proliferator-activated receptors (PPAR) is involved in energy homeostasis.

PPAR proteins are nuclear receptors activated the transcription of genes involved in lipid and glucose metabolism; they are of considerable importance in physical performance. They also perform many other important functions, for example cell differentiation, vascular homeostasis, tissue repair [10–12]. There are three PPAR isoforms: PPARα, PPARδ, and PPARγ [13]. Particularly, PPARα and its polymorphism play a central role in gene expression regulation involved in mitochondrial fatty acid oxidation and are associated with performance [14]. In the present study, the authors considered a polymorphic site in intron 7 (G/C polymorphism, rs4253778), in which the presence of the mutation determines an alteration in protein translation. This has an effect on the transcriptional activation of PPARα target genes and, consequently, leads to reduced fatty acid oxidation. The phenomenon causes lipid accumulation in the fatty tissue with subsequent weight and BMI increase [15].

The purpose of the study was to find out the best performance depending on different nutrients intake in 17 young girls who practiced gymnastics.

Gymnastics is an anaerobic sport, in which most of the energy to perform an exercise comes from the phosphocreatine system, as well as from the use of glycogen employed in anaerobic glycolysis. Since the discipline requires maximum effort in a minimum time, large calories expenditure may occur in a very short period. During a competition, artistic exhibitions last for a few seconds in the case of a windshield wiper, or about 90 seconds in beam or parallel exercises. Athletes who practice high-intensity sports should consume about 60–70% of carbohydrates in their diet [16]. Additionally, adequate protein intake is essential to excel in these sports because they are needed for muscle development. Also, when glycogen deposits are low, proteins become the most important substrate to produce energy. Consequently, caloric limitation may have a strong impact on growth and development, but also limit calcium and iron intake [17]. This could have such implications as amenorrhea, decreased bone density, reduced growth rate, and also worse performance [1, 18]. Therefore, the purpose of this study was to understand if there is specific nutrition to allow best performance.

Material and methods

Participants

The study involved 17 girls aged 10–14 years practising artistic gymnastics at the A.S.D. INDISCIPLINE in the Sprint Sport Center in Palermo, Italy. After requesting permission from the coaches and receiving the informed consent from the parents, the authors provided a specific snack before the training and administered a questionnaire at the end of it. In addition, a saliva sample was taken from each girl to carry out genetic analyses.

Anthropometric measurements

First, anthropometric measurements were performed for each girl [19], determining the weight and height. The height was measured in centimetres with a wall stadiometer, while the weight was indicated in kilograms by digital scales and used to calculate the body mass index (BMI) for all the athletes (Table 1).

Table 1. Anthropometric measurements

Year of birth	Age (months)	Weight (kg)	Height (cm)
2003	166.5 ± 4.80	50.73 ± 5.98	151.5 ± 3.42
2004	152.4 ± 3.13	50.74 ± 11.33	156.6 ± 8.02
2005	142.67 ± 3.21	40.23 ± 2.85	150 ± 1
2006	130.6 ± 2.97	41.26 ± 7.12	145 ± 7.58
Total	147.59 ± 14.20	46.09 ± 8.85	150.82 ± 7.35

Data expressed as means ± *SD*

Questionnaire and snacks composition

The questionnaire used in the study was specifically prepared and consisted of 13 questions. It was divided into two parts: in the first one, questions concerned the eating habits, while in the second part, the effects of the snack during workout were investigated. The questionnaire (ESPQ, Energy Self-Perception Questionnaire) was administered after the training during a period of 3 weeks, 2 times a week.

The snacks provided to the girls were chosen in relation to the energy requirements during workout. Two types of snacks: carb-based snacks and carb/protein-based snacks were consumed by the girls six times: for the first three times it was a cereal/carb bar with orange juice, and for the latter three times it was a sandwich with ham. Each cereal bar weighed 50 g and consisted of puffed rice, acacia honey, red cranberries, dry melon, dark chocolate, almonds, and sesame for a total of 180 kcal, and it was taken with 200 ml of 100% orange juice for a total of 102 kcal. The sandwich with ham weighed 80 g: 30 g of white bread and 50 g of ham, providing a total of 190 kcal. The snacks were consumed inside the gym, 45 minutes before starting workout.

Sample collection and genotyping

Saliva samples were collected in 15-ml sterile tubes and the gymnasts did not eat food for three hours before collecting the samples. The samples were appropriately stored at –20°C until use. Genomic DNA was isolated from peripheral blood cells with a PureLink blood kit (PureLink Genomic DNA, Thermo Fisher Scientific) from 1 ml of saliva. The genotyping was carried out by the polymerase chain reaction (PCR) in a total reaction volume of 50 µl, containing 50 ng of template, 1 µl of 10 mM deoxynucleoside triphosphate (dNTPs), 1 µl of 30 pmol each primer, and 5 µl of 10X reaction buffer with $MgCl_2$. The target sequence was amplified with the use of 5U/µl Dream Taq (Thermo Fisher Scientific) and the primers were 5'-ACAATCACTCCTTAAATATGGTGG-3' (forward) and 5'-AAGTAGGGACAGACAGGACCAGTA-3' (reverse).

The genotyping assay was: denaturation at 94°C for 5 minutes, followed by 35 cycles of denaturation at 94°C for 30 seconds, annealing at 59°C for 30 seconds, extension at 72°C for 30 seconds, and final extension at 72°C for 5 minutes. Taq I digestion was performed by adding 6 U of Taq I (Thermo Fisher Scientific), adding 2 µl restriction enzyme buffer in a volume of 20 µl, and incubating for 2 hours at 65°C. The fragments were separated on 8% vertical polyacrylamide gel at 100 V for 1 hour and visualized with ethidium bromide. The IBM SPSS Statistics, version 20, was used to perform all statistical evaluations; the value of $p < 0.05$ was assumed as the level of significance.

Results

All the gymnasts involved in the study completed 3 weeks of controlled consumption of snacks before training. According to the questionnaire, 82% of the responders regularly consume a snack in the afternoon and 52% eat a snack each day.

Snacks are the most frequently consumed food (46%), followed by fresh fruit and fruit juices (31%), chips (11%), and homemade cakes (9%). Only 3% of the subjects do not eat any snacks.

Most athletes (54%) regularly consume a snack 1 hour or half an hour before training. All athletes reported that they felt more fatigue during training if they did not eat any snack.

As for the snack that was administered, we participants were asked if there were any ingredients that they did not consume normally: 18% do not eat bread or ham, while 85% do not consume at least one cereal bar ingredient. In particular, 29% do not eat red cranberries, followed by sesame (18%), almonds and puffed rice (12%), and, finally, honey (6%).

Overall, 59% of the responders reported an improvement in their performance after the intake of cereal/carb bar and only in 6% the response was negative. Slightly different results were observed after the intake of a sandwich with ham: 47% felt more energy and 12% experienced more fatigue.

Definitely, most gymnasts prefer the cereal/carb bar (82%) and will try to make it at home; the remainder prefer the usual snack or not to eat anything. Although these snacks were very appreciated, only 41% would eat one before an important competition, perhaps because the large part of the responders prefer to stay fast instead of consuming other food (59%) (Table 2).

Table 2. Answers to the main questions

Questions	Options	Yes	No
Do you usually have a snack?		82%	18%
Do you usually have a snack each day?		52%	48%
Which kind of snack do you eat?	snacks	46%	
	orange or other fruit juice	31%	
	chips	11%	
	homemade cakes	9%	
	nothing	3%	
What performance change did you feel after eating a sandwich with ham?	more energetic	47%	
	no change	41%	
	more tired	12%	
What performance change did you feel after eating a cereal/carb bar?	more energetic	59%	
	no change	35%	
	more tired	6%	

Genotyping

With reference to the PPARα gene G/C polymorphism distribution in the studied Italian gymnasts, most of the girls represented the CC genotype (65%), while a small part had the other two genotypes, GC (23%) and GG (12%) (Figure 1).

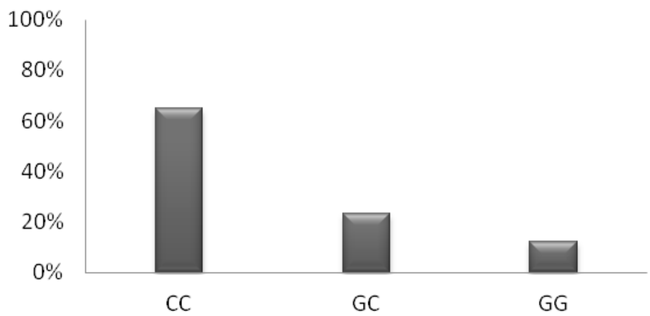

Figure 1. Percentage distribution of the genotypes (CC, GC, and GG) of the PPARα gene in the gymnasts

Furthermore, with regard to the correlation between genotype and BMI, the possible association between the C allele and the increase of BMI was particularly investigated. It was observed that the average BMI equalled 20.05 ± 2.8 kg/m^2 in the group with the CC genotype, 19.6 ± 2.8 kg/m^2 with the GC genotype, and 20.2 ± 2.8 kg/m^2 with the GG genotype. The correlation between genotype and BMI was assessed by the χ^2 test; the p value was 0.37.

Discussion

The aim of the study was to investigate the effect of a specific snack with well-defined composition, consumed before the training, on gymnasts' performance.

The results obtained showed that most of the gymnasts declared an improvement in their performance after eating a snack, especially a cereal/carb bar, while a ham sandwich seemed to have a disadvantageous effect. Actually, this outcome was predictable because the digestion of a snack rich in proteins is slower than that of a carb bar and orange juice.

With regard to the genotype, we did not find any significant difference in the distribution since most of the girls represented the CC genotype. It is notable that a large part of the gymnasts had the variant predisposing to greater accumulation of lipids, so it is important to emphasize that it is necessary to be mindful of eating habits and lifestyle in order to prevent the onset of overweight [20]. No statistically significant correlation between genotype and BMI was found. Although this may seem a negative result, it must be considered that the group taken into account was composed of pre-adolescent girls, exposed to a series of changes.

Probably, the main limitation of the study is the small group of participants. This is a preliminary study that should be deepened by increasing the number of subjects, as well as diversifying the type of snacks administered and increasing the time of the study. In addition, there was no control group that would not consume any snack before training; this would be important to confirm the obtained results. The authors believe that further research including more athletes and conducted for a longer time could provide more interesting and reliable data on the influence of nutrition before training, especially in the context of an important competition.

Conclusions

Most gymnasts experienced an improvement in their performance after eating a snack, especially a cereal/carb bar. The preliminary study should be deepened by increasing the number of subjects, diversifying the type of snacks administered, and increasing the time of the study. It is important to be mindful of eating habits and lifestyle in order to prevent the onset of overweight.

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