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THE INFLUENCE OF MEDIUM CHAIN TRIGLYCERIDE SUPPLEMENTATION ON HIGH-INTENSITY ENDURANCE EXERCISE

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Abstract: Proper nutrition is responsible for regulating all the metabolic processes that involve the human body, especially with regard to physical performance in sports. As for the means of energy supply, carbohydrate is the main source for long-lasting aerobic activities, but muscle glycogen is limited. For this reason, supplementation of medium-chain triglycerides (MCT) has been studied as an important energy source that can help reduce the use of muscle glycogen, in a way that would improve the performance of athletes. Therefore, the present study aimed to analyze the effects of MCT supplementation in athletes who perform high-intensity endurance training. The research was developed with 10 (ten) amateur runners, 5 (five) women and 5 (five) men. Two 10km races were carried out with a difference of 6 days between them. On both days, the athletes received a glass of water 10 minutes before the start of the races, with half of the athletes ingesting only water, while the other half of the runners ingested a mixture of water + 20ml of liquid TCM (colorless and tasteless). Those who received supplementation on the first day ingested only water on the second run and vice versa. At the end of the two races, the athletes answered a physical performance questionnaire prepared by the researcher and a mood questionnaire entitled "Brunel's Mood Scale", in order to verify the disposition and fatigue of the athletes. Statistical analysis was performed and the T-student test was applied to compare the groups for parametric variables and the Mann-Whitney test for non-parametric variables. The significance level adopted was 5% ($p<0.05$). It was found that there was no statistically significant difference with regard to the use of TCM supplementation in improving the performance and mood sensations of athletes after running, but 30% of athletes reported a feeling of heartburn and 20% of intestinal discomfort. Therefore, it is concluded that TCM supplementation for running up to 10km does not seem to promote an improvement in performance that justifies its use, and further studies are needed so that the benefit of this supplementation can be identified.

Keywords: Medium chain triglycerides; Endurance; Physical performance.

INTRODUCTION

Adequate nutrition is responsible for regulating all the metabolic processes that involve the human body, being essential to preserve lean body mass, repair cells, synthesize new tissues, optimize skeletal structure, maximize transport and use of oxygen, among others. functions.

In addition, with regard to physical performance, adequate nutrition provides an energy source for biological work, as well as providing the nutrients that will allow transforming the potential energy of food into kinetic energy of movement (McARDLE; KATCH; KACTH, 2016).

In view of this, from the ancient Olympics to the present day, dietary practices with improved nutrition for athletes are used as strategies to improve physical performance in exercises (McARDLE; KATCH; KACTH, 2016).

With regard to endurance exercises, such as long running or cycling training, the energy expenditure in this type of activity is very high, so that the energy demand has been the object of study with the aim of improving the performance of athletes. this type of sport (FERREIRA; BARBOSA; CADDIA, 2003).

Carbohydrates are the main sources of energy supply for long-term aerobic activities, but muscle glycogen is limited and individuals involved in high-intensity training or long-distance running may run the risk of running out of muscle glycogen before the end of training or exercise, as a result of its high

utilization rate (MAHAN; RAYMOND, 2018).

For this reason, supplementation of medium-chain triglycerides (MCT) has been studied as an important source of energy that, when combined with carbohydrate, can help reduce the use of muscle glycogen, in a way that would improve the performance of endurance athletes. of high intensity (FERREIRA; RIBEIRO; SOARES, 2001).

Medium chain triglycerides are responsible for providing a faster source of fatty acids, because they contain saturated fatty acids of 8 to 10 carbon atoms in their chains. Thus, during the digestion process, MCTs are hydrolyzed through the action of lipase in the mouth, stomach and duodenum, thus forming glycerol and medium-chain fatty acids (MCFA). Thus, considering that MCFA are water-soluble, they are transported through the intestinal mucosa directly to the hepatic portal vein. From that moment on, they move rapidly across the plasma membrane, diffusing through the mitochondrial membrane to be oxidized (McARDLE; KATCH; KACTH, 2016).

In view of this ease of MCT oxidation, there is an increase in plasma free fatty acid levels, which can help preserve muscle glycogen during high-intensity exercise (McARDLE; KATCH; KACTH, 2016).

It so happens that research has been carried out with TCM supplementation in practitioners of high-intensity physical activities, but the benefits regarding the improvement of performance were inconclusive. As an example, we can mention the study developed by Angus et al. (2000), which, with the aim of verifying the effect of carbohydrate ingestion only and carbohydrate ingestion combined with TCM, evaluated eight cycling athletes who covered 100Km, and during the course, compound solutions were consumed every 15 minutes per 6% carbohydrate or 6% carbohydrate + 4.2% TCM. The results proved that carbohydrate supplementation actually improved the athletes' performance, however the addition of MCT did not cause any additional improvement in performance.

Another study developed by Jeukendrup et al. (1996), aimed to evaluate existing differences in the rate of carbohydrate oxidation during exercise when there was ingestion of MCT. In view of this, nine cyclists who pedaled 180 minutes were evaluated, and every 20 minutes during the exercise they received solutions of 150g/L of carbohydrate, another containing 70% of carbohydrate + 30% of TCM (29g), another solution of 150g of carbohydrate + 20g of TCM and finally, a placebo solution. At the end of the analysis, it was found that plasma free fatty acids showed high concentrations during all exercise sessions, whereas plasma ketones increased their concentration significantly after MCT consumption. Therefore, it was concluded in this study that the ingestion of MCT together with carbohydrate did not influence the use of glycogen during 180 minutes of exercise.

However, we can observe that the aforementioned studies were developed more than 20 years ago and, recently, more specifically in the year 2018, a new study developed by Ying Wang et al. (2018), which analyzed that medium-chain triglycerides increase exercise resistance through increased biogenesis and mitochondrial metabolism, revealing a new role for MCTs during physical exercise.

For this reason, lipid supplementation, more specifically medium-chain triglyceride supplementation, has been the object of study aimed at improving performance during endurance practice, given that MCT supplementation can increase the use of free fatty acids as a source of energy, helping to maintain muscle glycogen during exercise.

Therefore, studies are needed that seek to relate the use of medium-chain triglycerides

supplementation with the improvement of sports performance during endurance exercises such as running, for example.

In this context, the objective of this scientific initiation work is to analyze the effects of supplementation of medium chain triglycerides in athletes who perform running training in the city of Bauru/SP, in order to verify if there is an improvement in physical performance with the use of TCM.

MATERIALS AND METHODS

RESEARCH OUTLINE

This is an analytical, cross-sectional study that aims to analyze the relationship between supplementation of medium-chain triglycerides with the improvement in the performance of athletes during the practice of endurance exercises, more specifically, in running training.

OPERATIONAL ROUTINE

The research was developed with amateur runners from a running team located in the city of Bauru/SP. To authorize the research, a request for consent was sent to the person in charge of the team, with a subsequent declaration of acceptance by the management.

The research was initiated after authorization by the Research Ethics Committee (4,624,795) and the participants signed the Informed Consent Form (TCLE).

Intermediate amateur runners of both sexes, between 18 and 55 years old, were included in the research. The exclusion criteria adopted were: athletes who were not within the age range, who had kidney problems, hypertension or some heart dysfunction.

Therefore, to carry out research on the influence of medium-chain triglycerides on the performance of athletes from a running group, there was help from the coordinating coach of the Superatis running group in the city of Bauru/SP, who selected 10 runners amateurs with a similar level of physical conditioning, through the analysis of the database it has on the physical performance of the sportsmen who are part of the racing team.

After the selection, the dates were scheduled with the participants to carry out two races with a distance of 10 km each, which took place on 11/28/2021 and 12/04/2021 at 6 am, and the two races were carried out along the same route. Participants were randomized into 2 groups of 5 members. About 10 minutes before each race, a glass of water was provided to all runners, and half of the athletes (n=5) received only water, performing the placebo run, while the other half of the runners received a mixture of water + 20ml of liquid TCM (colorless and tasteless), performing the TCM run. The group that received TCM supplementation on the first day of the race was not supplemented on the second day and vice versa. On both dates, participants were not informed whether the liquid ingested was placebo or TCM. Table 1 shows the breakdown of runners according to race dates.

Date of race	Runners (n=10)	Supplementation
11/28/2021	GROUP 1 (n=5)	PLACEBO
	GROUP 2 (n=5)	TCM
12/04/2021	GROUP 1 (n=5)	TCM
	GROUP 2 (n=5)	PLACEBO

Table 1 – Classification regarding supplementation ingested by runners

Source: Elaborated by the author.

It is important to clarify that studies show that MCT doses greater than 30g or 30ml can cause gastrointestinal discomfort, so the amount of 30ml is the tolerable intake limit for application in sports (BECKER, L. K. et al, 2016). In view of this, a dosage of 20ml was provided to the runners who participated in the research, that is, a dosage of less than 30ml in order to avoid gastrointestinal discomfort.

After the race, the athletes answered the physical performance questionnaire prepared by the researcher, as well as the mood questionnaire entitled "Brunel's Mood Scale", adapted from the literature (ROHLFS et al., 2008).

Thus, based on the data obtained through the questionnaires, the researcher developed a comparative study of the performance of sportsmen in relation to the "placebo" and "TCM" groups, with the aim of verifying whether there was any improvement in physical performance during the race. in the group that consumed medium-chain triglycerides supplementation.

PHYSICAL PERFORMANCE QUESTIONNAIRE

To verify the physical performance of the runners, the researcher created a questionnaire with some relevant information for the development of the present study.

The physical performance questionnaire allowed the collection of information regarding weight and height in order to determine the BMI of the runners.

It is also composed of a list of 19 different types of symptoms that sportsmen could present during races.

Finally, it aims to evaluate the time taken at the end of each race, as well as what was the pre-workout meal of the runners, with the objective of verifying the amount of macronutrients consumed.

BRUNEL MOOD SCALE (BRUMS)

With regard to the Brunel Mood Scale (BRUMS), it was developed with the aim of measuring the mood state in adults and adolescents, and is also used as a form of intervention in sport psychology to assess the individual's mental disposition. In Brazil, there are few instruments available to assess psychology in sport, and the BRUMS, in its Portuguese language version, is considered an appropriate instrument for assessing humor profiles in sports practices (ROHLFS et al., 2008).

The BRUMS is composed of 24 mood indicators ranging from feelings of anger and dissatisfaction to feelings of disposition and vigor. Evaluators must respond according to a scale from 0 (not at all) to 4 (extremely) points. For the development of the research, the participants responded according to the sensations they had right after the end of the races.

It is necessary to clarify that the 24 items of the Brunel Mood Scale make up some subscales, more specifically 6 (six) types, namely: tension, depression, anger, vigor, fatigue and mental confusion. Each subscale is composed of four of the 24 items present in the scale, and from the sum of the responses of the groups of items of each subscale, a score is obtained that can vary from 0 to 16 (ROHLFS, 2006; DESCHAMPS, 2008). Table 2 demonstrates the subscale definitions.

Subscale	Definition
Tension	State of musculoskeletal tension and worry
Depression	Emotional state of discouragement, sadness, unhappiness
Anger	State of hostility towards others
Force	State of energy, physical vigor
Fatigue	State of tiredness, low energy
Mental confusion	Stunned state, instability in emotions

Table 2 – Brunel Mood Scale Subscales

Source: BRANDT, R. et al, 2010.

Thus, from the data collected through the Brunel Mood Scale, it will be possible to identify, through statistical analysis, the mood states of the runners in both races, with the objective of verifying if there was any alteration regarding the supplementation of TCM.

STATISTICAL ANALYSIS

The data obtained were entered into a database in Microsoft Excel spreadsheets, version 2019. The difference between the data was established using the T-student or Mann-Whitney U tests, for parametric and non-parametric variables, respectively. For data analysis, an evaluation of the surveyed population was carried out, with calculations of central tendency and dispersion averages for continuous variables and frequency for categorical variables.

Data analyzes were performed using SigmaPlot software for Windows v12.0 (Systat Software Inc., San Jose, CA, USA). The significance level adopted was 5% ($p<0.05$). The results were demonstrated in Tables and in an analytical and descriptive way.

RESULTS

Ten athletes were evaluated, 5 women and 5 men, with a mean age of 37.2 ± 8.23, with no statistical difference in age between genders ($p = 0.206$), as shown in Table 3.

According to the Nutritional Status of the runners, it was observed that most participants were classified as eutrophic (60%) and 40% classified as overweight, as shown in Table 4.

Classification	IMC (kg/m²)	Nº (%)
Low weight	<18,5	0 (0%)
Eutrophy	18,5 – 24,9	6 (60%)
Overweight	≥ 25 a 29,9	4 (40%)
Obesity I	30,0 a 34,9	0 (0%)
Obesity II	35,0 a 39,9	0 (0%)
Obesity III	≥ 40,00	0 (0%)

Table 4 – Classification of nutritional status according to BMI (kg/m²) for adults

Source: Elaborated by the author. Values expressed in absolute value and in percentage.

From the analysis of the collected data, it was verified through the physical performance questionnaire prepared by the researcher that 20% of the participants reported feeling intestinal discomfort after the race in which they were supplemented with TCM. In addition, 10% reported feelings of loss of strength and generalized fatigue and 30% had difficulty maintaining running pace with TCM supplementation. On the other hand, in the race where the participants received the placebo, 10% reported intense thirst and a feeling of loss of strength and 20% had difficulty maintaining the pace of the race. The most relevant data from the questionnaire was the fact that 30% of the research participants reported feeling heartburn when ingesting MCT, as seen in Table 5.

It was also verified, through the analysis of the final times of the two races, that in the race in which the participants were supplemented with TCM, the mean time was 55'23" ± 0.002, while in the race in which the athletes ingested only water had an average of 55'56" ± 0.003, so there was no statistically significant difference between the times of the races, as shown in Table 6.

Regarding the consumption of macronutrients in the pre-workout meal of both races, there was no statistically significant difference regarding the intake of carbohydrates, proteins and lipids. Therefore, the consumption of this meal did not interfere with the intake of medium-chain triglycerides supplementation, as shown in Table 7.

Regarding the Brunel Mood Scale (BRUMS), after analyzing the data collected based on the 24 mood indicators that the research participants answered after the end of the races, the following response averages were obtained according to Table 8.

These 24 items mentioned above make up the 6 subscales of the Brunel Mood Scale, they are: tension, depression, anger, vigor, fatigue and mental confusion. Each subscale contains four items shown in Table 8, and from the sum of the responses of the items belonging to

Variable (n=10)	Female gender	Male gender	Value of P	Total
Age (years)	33,6±7,83	40,8±8,70	0,206	37,2 ± 8,23

Table 3 – Age according to sex

Source: Elaborated by the author. Values expressed as mean ± standard deviation. For comparison between groups, the T-student test was used.

Classification	Number of participants TCM (n=10) (%)	Number of Participants - Placebo (n=10) (%)
Intestinal Discomfort	2 (20%)	0 (0%)
Diarrhea	0 (0%)	0 (0%)
Very intense thirst	0 (0%)	1 (10%)
Difficulty concentrating	0 (0%)	0 (0%)
Cramps	0 (0%)	0 (0%)
Fainting	0 (0%)	0 (0%)
Pallor	0 (0%)	0 (0%)
Insensitivity of hands	0 (0%)	0 (0%)
Visual changes	0 (0%)	0 (0%)
Feeling of loss of strength	1 (10%)	1 (10%)
Generalized fatigue	1 (10%)	0 (0%)
Headache	0 (0%)	0 (0%)
Hallucinations	0 (0%)	0 (0%)
Somnolence	0 (0%)	0 (0%)
Momentary loss of consciousness	0 (0%)	0 (0%)
Convulsions	0 (0%)	0 (0%)
Interruptions in sweat production	0 (0%)	0 (0%)
Difficulty maintaining running pace	3 (30%)	2 (20%)
Heartburn	3 (30%)	0 (0%)

Table 5 – Classification of the Physical Performance Questionnaire.

Source: Elaborated by the author. Values expressed in absolute value and in percentage.

Variable (n=10)	Race with TCM	Race with Placebo	Value of P	Total
Time (minutes)	55,39 ± 4,213	55,94 ± 4,675	0,784	55,66 ± 4,230

Table 6 – Comparison of average race times.

Source: Elaborated by the author. Values expressed as mean ± standard deviation. For the comparison between the groups, the T-student test was used.

Variable (n=10)	Race with TCM	Race without TCM	Value of P
Carbohydrate (grams)	19,66 ± 14,10	25,19 ± 18,93	0,491
Carbohydrate (%)	41,90 ± 27,66	49,09 ± 28,15	
Protein (grams)	4,625 (0,82-15,25)	5,345 (0,78-6,65)	0,939
Protein (%)	10,05 (4,1-27)	9,55 (4,1-19,6)	0,849
Lipids (grams)	5,51 ± 5,34	4,96 ± 5,75	
Lipids (%)	20,93 ± 17,36	17,66 ± 13,17	0,836

Table 7 – Consumption of pre-workout macronutrients.

Source: Elaborated by the author. Values expressed as median (interquartile ranges) and mean ± standard deviation. T-Student test was used for normal variables and the Mann-Whitney test for non-normal data.

Mood	Race with TCM	Race with Placebo
Terrified	0	0
Cheered up	3,1 ± 0,7	2,2 ± 0,74
Confused	0	0
Exhausted	0,8 ± 0,98	0,9 ± 0,83
Depressed	0	0
Sad	0	0,1 ± 0,3
Irritated	0,1 ± 0,3	0
Exhausted	1,2 ± 1,4	1,3 ± 0,9
Insecure	0	0
Sleepy	0	0
Angry	0	0
Sad	0	0
Anxious	0,3 ± 0,64	0,2 ± 0,6
Worried	0	0,1 ± 0,3
In the mood	2,5 ± 0,92	2,4 ± 1,11
Unhappy	0	0
Disoriented	0	0
Tense	0,1 ± 0,3	0
Angry	0	0
With energy	2,6 ± 0,8	2,3 ± 1,26
Tired	1,5 ± 1,02	1,4 ± 0,66
Grumpy	0	0
Alert	1,4 ± 1,2	1,2 ± 1,32
Undecided	0	0

Table 8 – Average Brunel Mood Scale score in both races.

Source: Elaborated by the author. Values expressed as mean ± standard deviation.

Subscale	Race with TCM	Race without TCM	Value of P
Tension	0 (0-0)	0 (0-0)	1,000
Depression	0 (0-0)	0 (0-0)	0,368
Anger	0 (0-0)	0 (0-0)	0,368
Force	9,6 ± 3,01	8,1 ± 3,33	0,329
Fatigue	3,5 ± 3,11	3,6 ± 1,8	0,934
Mental confusion	0	0	-

Table 9 – Sum of BRUMS subscale items in both runs.

Source: Elaborated by the author. Values expressed as median (interquartile ranges) and mean ± standard deviation. T-Student test was used for normal variables and Mann-Whitney test for non-normal data.

each one, we obtained a comparison between the two races. Therefore, there was no statistically significant difference in feelings of tension, depression, anger, vigor, fatigue and mental confusion between the race in which TCM supplementation was taken and the race without supplementation, as shown in Table 9.

Therefore, in view of all the data analyzed, it was verified that there was no statistically significant difference in relation to the use of TCM supplementation, both in terms of performance improvement and in the athletes' mood sensations after running.

DISCUSSION

Due to the intensity and energy expenditure expended by athletes who perform endurance training, the improvement of nutritional capacity is increasingly required among these individuals. Furthermore, prolonged physical effort leads to the depletion of muscle glycogen, a factor that directly influences the drop-in performance, in addition to causing fatigue and injuries (FERREIRA; RIBEIRO; SOARES, 2001).

In view of this, the search for nutritional strategies aimed at improving performance during the practice of this type of sport has been developed over the years. Carbohydrates act as the main energy substrate, especially during the practice of intense physical exercises, because the energy derived from blood glucose and the hydrolysis of hepatic and muscle glycogen energetically supply the contractile elements of the muscle. It turns out that carbohydrates present more intense use and depletion during strenuous training when compared to fat and protein, which is why daily carbohydrate intake maintains the relatively limited reserves of glycogen in the body in practitioners of physical activities (McARDLE; KATCH; KACTH, 2016).

Furthermore, longer training sessions involving endurance activities lead to a reduction in glycogen reserves so that lipid catabolism contributes to a progressively greater percentage of energy from the mobilization of fatty acids in adipose tissue and liver (McARDLE; KACTH, 2016).

That said, lipid supplementation, more specifically medium-chain triglyceride supplementation, has been the subject of study aimed at improving performance during endurance practice, because MCTs contain saturated fatty acids in their chains with 8 to 10 carbon atoms and during the digestion process they are hydrolyzed forming glycerol and medium chain fatty acids (MCFA). MCFAs have water solubility which allows them to move through the intestinal mucosa directly into the hepatic portal vein. Once in tissues, MCFAs move rapidly across the plasma membrane and diffuse to the mitochondrial membrane to be oxidized. In view of this faster and easier oxidation, MCTs are generally not stored as body fat. Therefore, intake of TCM supplementation can increase the use of free fatty acids as an energy source, helping to maintain muscle glycogen during exercise (FERREIRA, RIBEIRO, SOARES, 2001; McARDLE, KATCH, KACTH, 2016).

There are some studies that were developed with the aim of relating TCM supplementation with the improvement in the performance of high-intensity physical activities, but most of them are inconclusive. Let's see, for example, the study developed by Angus et al. (2000), which verified in cycling athletes the effect of carbohydrate ingestion alone and carbohydrate ingestion combined with TCM. The results proved that carbohydrate supplementation actually improved the athletes' performance, however the addition of MCT did not cause any additional improvement in performance.

Another study developed by Jeukendrup et al. (1996), aimed to evaluate existing differences in the rate of carbohydrate

oxidation during cycling exercise when there was MCT ingestion, however, it was concluded that MCT ingestion together with carbohydrate did not influence the use of glycogen during 180 minutes of exercise.

Thus, in view of the inconclusive studies that relate TCM supplementation with the improvement of physical performance, the researcher collected several data involving the participants of the races, which were evaluated to verify if there was any relationship in the use of triglyceride supplementation. of medium chain with the improvement of the sporting performance during the practice of running.

The effectiveness of using TCM is questioned, precisely because of the inability of individuals to tolerate the substantial amount of TCM oils necessary for a considerable metabolic impact, with a total intake of 30g considered as the gastrointestinal tolerance limit (CALBET, J.A. et al, 2011; BECKER, L. K. et al, 2016). For the development of the research, a dosage of 20ml of TCM was provided for the runners, that is, a dosage lower than 30ml in order to avoid gastrointestinal discomforts. However, after tabulating the data referring to the physical performance questionnaire, it was verified that in the race of the "placebo" group, in which there was no TCM supplementation, no gastrointestinal symptoms were reported by any of the participants, unlike the race with TCM supplementation. TCM in which 20% of the runners reported having felt some type of intestinal discomfort during the run and 30% reported feeling heartburn.

With regard to the improvement of the runners' performance, it was found that despite the literature bringing the possibility of medium chain triglycerides increasing the use of free fatty acids as an energy source and helping to maintain muscle glycogen during exercise, favoring the improvement in physical performance (McARDLE; KATCH; KACTH, 2016), there was no statistically significant difference between the final time of the race in which the athletes were supplemented with MCT and the race in which they ingested only water.

In addition to improving performance, some studies report that TCM supplementation may favor the reduction of the feeling of fatigue during the practice of endurance exercises, thus improving some mood states in athletes (BECKER, 2016).

For this reason, the research participants responded to the Brunel Mood Scale (BRUMS) at the end of each race, given that it is an intervention tool in sport psychology to assess the individual's mental disposition. This way, the mood state of the runners at the end of both races was verified, however there was no statistically significant difference in terms of feelings of tension, depression, anger, vigor, fatigue and mental confusion between the race in which there was ingestion of the TCM supplementation and running without supplementation.

Therefore, although medium-chain triglycerides are related to physiological aspects that involve energy supply, maintenance of muscle glycogen and reduction of fatigue, factors that would consequently lead to improved performance, this research did not identify significant statistical data that could corroborate such statements, requiring the development of new studies regarding the benefits of TCM supplementation for the practice of endurance sports.

FINAL CONSIDERATIONS

TCM supplementation for running up to 10km does not seem to promote performance improvement that justifies its use, despite the studies cited throughout the research reporting that the use of this supplementation could save body glycogen stores, improve performance and the feeling of fatigue.

It was observed that the amount of MCT used in the research was lower than the recommendation found in the literature (30g) and, even so, 30% of the athletes reported a feeling of heartburn and 20% of intestinal discomfort.

It is concluded that the use of TCM supplementation needs more studies that use different analysis methods, such as a greater number of participating athletes, longer stimulation time and different dosages so that the benefit that justifies the use of this supplementation in sports can be identified. of endurance.

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