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Gastrointestinal symptoms and diseases modified by exercise and the role of nutrition

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Abstract

In our time, the positive contribution of exercise to health is confirmed. However, negative effects have also been reported. This study tries to clarify the field about the effect of exercise on the gastrointestinal system and the role of nutrition. To achieve this, research has been done on scientific databases. Several keyword combinations were used and the papers identified were categorized. The findings were presented at the level of mechanisms, at the level of symptoms and finally at the level of diseases. Positive effects have been found in colon cancers of gastric cancer in gallstones, inflammatory bowel disease, diverticular disease and constipation. In terms of symptoms, exercise induces gastroesophageal reflux, transient, abdominal pain, bleeding, nausea and vomiting. In diseases, exercise affects peptic ulcer, liver disease, and is associated with abdominal trauma and eating disorders. Specific symptoms of gastrointestinal tract can be avoided if the athlete doesn't eat 30 minutes before exercise. Hypertonic fluids cause severe symptoms and high fiber may cause vomiting. Therefore, the knowledge of these elements is important and useful in designing exercise programs with the least negative health effects.

Keywords: Exercise; Gastrointestinal system; Nutrition; Diet; Effect.

1 Introduction

The positive effect of exercise, in particular on the cardiovascular and musculoskeletal health, is now proven (World Health Organization, 2010). That's why doctors and trainers suggest the general population to be active. However, exercise has negative effects on health too. Generally, the more intense is the exercise, the more problems are presented.

Exercise with duration over two hours with intensity greater than 60% of VO2max appears to be the threshold where significant gastrointestinal disturbances are observed, regardless of the individual's physical condition (Costa et al., 2017a).

The incidence of gastrointestinal symptoms has been reported to be at the level of 70% with unknown pathophysiology (Steege and Kolkman, 2012).

In particular, Worobetz and Gerrard (1985) estimate the symptoms of gastrointestinal truck at 81%, Riddoch and Trinick (1998) at 83%; Peters (1999) at 21% and Steege (2008) at 45%. In terms of upper gastrointestinal tract, the incidence of symptoms is estimated by Keeffe (1984) at 23% by Worobetz and Gerrard (1985) at 58% and Steege (2008) at 45%. The incidence of symptoms of lower gastrointestinal truck, on the other hand, is estimated by Riddoch and Trinick (1998) at 88%, by Keeffe (1984) at 66% and by Worobetz and Gerrard (1985) at 61%. Especially distance runners experience gut problems related to exercise at 30-90% (Oliveira et al., 2014).

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Therefore, although exercise positively influences overall health, it can cause problems in various systems, including gastrointestinal system. Below is an investigation of the effect of exercise on the gastrointestinal tract, including both positive and negative effects.

The aim of this study is to clarify the effect of exercise on gastrointestinal system (symptoms, diseases) and to show how the nutrition changes this effect. To achieve this the symptoms and diseases of gastrointestinal tract that caused or modified by the exercise are presented and also the role of nutrition is commended.

2 Method

To identify the symptoms caused by the exercise, its effect on the various gastrointestinal diseases and the role of nutrition, a search was made in scientific databases for the detection of relevant studies. In particular, the databases from which studies were retrieved were Pubmed and Scopus.

The index words used were "*exercise*", "*physical activity*", "*gastrointestinal disease*", "*intestine*", "*cancer*", "*nutrition*" etc in various types and combinations. The studies included were that have content consistent with the study's objectives and helped to clarify the situation. The results were categorized into three levels: Mechanisms, symptoms and effects on gastrointestinal diseases.

There was no restriction on publication time because, due to the limited literature on the subject. Even old research is valuable because little literature exist for this specific subject.

Only publications related to humans were included. They have also to be written in English, otherwise were not eligible. Only research articles and reviews were considered, not syntax, commentary, letter or guideline.

3 Mechanisms of symptoms

The literature regarding the pathophysiology of the gastrointestinal effects of exercise is not vast. The mechanisms that are implicated are increased activity of the sympathetic nervous system and decreased visceral flow during exercise (Steege and Kolkman, 2012).

A more analytical approach states that the effects of intense exercise are caused by recurrent intestinal ischemia without adequate recovery intervals, b) due to an effect on the intestinal motility, associated with hypothermia and consequent ischemia and change in intestinal nerve activity and c) due to local and systemic inflammation associated with intestinal trauma, increased intestinal permeability, endotoxemia and oxidative stress (Costa et al., 2017a).

It has been found that running for 90 minutes at a high rate causes damage to the small intestine and increases intestinal permeability. However, these changes do not seem to correlate with the occurrence of symptoms during exercise (Karhu et al., 2017). It also does not appear that the increase in permeability of the intestine due to exercise can cause toxinemia (Yeh et al., 2013).

The physiological and pathophysiological changes occurring during exercise are the following (Steege and Kolkman, 2012):

During exercise, a visceral flow reduction of up to 80% is observed compared to visceral flow of rest. The decrease becomes stronger with younger age, with high intensity and long duration of exercise, with the presence of dehydration and high environmental temperature. Reduction of visceral flow is restricted by food intake.

If the reduction in visceral flow is greater than 50%, then gastrointestinal ischemia is induced. Consequences are epithelial damage, nutrient malabsorption, gastrointestinal hemorrhage and increased intestinal permeability.

Higher gastrointestinal motility is observed, primary or secondary due to gastrointestinal ischemia. In addition reduced esophageal peristalsis and decreased esophageal sphincter tone are observed. The consequence of these is delayed gastric emptying, leading to regurgitation, nausea and vomiting.

Concerning secretion and absorption of gastrointestinal, it is reported that secretion is likely to remain unchanged. Absorption of water also does not change. In addition, limited carbohydrate absorption is observed. The consequence is osmotic diarrhea due to overload of non-absorbed carbohydrates or hypertonic fluids.

4 Symptoms

Exercise has also been associated with adverse effects on the gastrointestinal tract, ranging from insignificant to potentially life-threatening (table 1).

Table 1 Gastrointestinal Symptoms that exercise can modify

Symptom	Reference
Gastroesophageal reflux	Bi and Triadafilopoulos, 2003 Viola, 2010 Collings et al., 2003
Diarrhea	Koon et al., 2017 Oliveira, 2017 Butcher, 1993
Abdominal pain	Muir, 2009 Morton and Callister 2000 Morton and Callister 2002
Gastrointestinal haemorrhage	Pahor et al., 1994 Keeffe et al, 1984 McMahon et al., 1984
Nausea and vomiting	Sullivan, 1981 Oliveira and Burini, 2009 Peters et al., 1999
Constipation	Bi and Triadafilopoulos, 2003 Cordain et al. 1986 Meshkinpour et al., 1998 Everhart et al., 1989 Donald et al., 1985 Peters et al., 2001

Especially in the esophagus is induced gastroesophageal reflux and inhibition of gastric fluid production at stomach. Intense exercise can affect the absorption of substances in small intestine. Finally, in the large intestine, intense exercise can cause bleeding (Bi and Triadafilopoulos, 2003).

Gastroesophageal reflux is the most common symptom of upper gastrointestinal in athletes. It is more common in endurance sports and where exercise takes place immediately after lunch. Both the intensity and the duration of the symptom increase when exercise intensity exceeds 90% VO2max (Viola, 2010). Athletes have a threefold

chance of having gastroesophageal reflux when they run within 45 minutes of the meal compared to running on an empty stomach (Collings et al., 2003).

Another common symptom of gastrointestinal system in athletes is diarrhea (athletes diarrhea) (Koon et al., 2017). It is expected that athletes will experience unpleasant feelings when episodes of diarrhea occur during training and especially during competition. The pathophysiology of this condition is not known. The transfer of large amounts of blood from the intestine to the muscles is suspected, resulting in reduced visceral blood flow (Oliveira, 2017; Butcher, 1993).

Also, the symptoms associated with exercise include abdominal pain. Exercise induced transient abdominal pain (ETAP) has been described at running, swimming and riding. It is a situation that experiences over 70% of runners. It can affect any part of the abdomen, but it is usually on the side walls and most commonly on the right side. The pain is characterized as acute or cramp depending on the intensity of it (Muir, 2009). Sometimes it reflects on the shoulder and reliefs automatically. The athletes with ETAP reduce the intensity of the exercise or interrupt the effort to reduce the pain. There are several approaches to the pathophysiology of this condition. One of them attributes the symptom to peritoneal irritation, ischemia of the diaphragm and distension of the visceral ligaments (Morton and Callister 2000, Morton and Callister 2002).

A prospective study, aimed at studying the effect of exercise on gastrointestinal haemorrhage, concluded that there was a positive effect. The interpretation given is that increased gastrointestinal blood flow in physically active individuals reduced the risk (Pahor et al., 1994). However, other studies regarding exercise and gastrointestinal bleeding have resulted in different results. In particular, exercise can cause bleeding, that is not obvious and self-limited, but there is also a case where it is massive. Gastrointestinal hemorrhage may cause iron deficiency anemia. Keeffe et al (1984) examined 707 marathon participants and discovered a high incidence of gastrointestinal symptoms. 1.2% to 2.4% had diarrhea with blood. McMahon et al. (1984) examined faecal samples of 32 runners before and after the marathon and found after the race blood in 22% of them. Although most of the problems caused by exercise are minor, bleeding can have significant effects.

Athletes often experience episodes of nausea and vomiting when they have intense and prolonged exercise (Sullivan 1981; Oliveira and Burini, 2009). The characteristic of this condition is that these symptoms are not limited during exercise but also occur during rest (Peters et al., 1999).

The study' results regarding the effect of aerobic exercise on the gastrointestinal tract are contradictory (Bi and Triadafilopoulos, 2003). Some studies have shown a significant reduction in the time of food pass in the intestine (Cordain et al. 1986), while others the opposite (Meshkinpour et al., 1998). Even though sedentary individuals may benefit from aerobic exercise with cardiovascular improvement, there is no evidence that aerobic exercise positively influences chronic constipation (Bi and Triadafilopoulos, 2003). Similar findings have led to studies showing an inverse relationship between constipation and physical activity (Everhart et al., 1989; Donald et al., 1985). However, this effect is not considered confirmed (Peters et al., 2001).

5 Diseases

Exercise can also influence diseases of gastrointestinal track (table 2).

Table 2 Gastrointestinal Diseases that exercise can modify

Disease	Reference
Cancer (bowel)	Bi and Triadafilopoulos, 2003 Oliveria and Christos, 1997 Colditz et al., 1997 World Cancer Research Fund, 1997 Colditz et al., 1997
Cancer (stomach)	Wannamethee et al., 2001 Giovannucci et al., 1995 Lee, 1994
Cholelithiasis	Leitzmann et al., 1999; Leitzmann et al., 1998; Rissanen and Fogelholm, 1999
Inflammatory bowel disease	Bilski et al., 2014; Koon et al., 2017 Sonnenberg, 1990 Robinson et al., 1998
Peptic ulcer	Cheng et al., 2000
Diverticular disease	Strate et al., 2009 Hjern et al., 2012 Aldoori et al., 1995
Liver disease	Schlang and Kirkpaptrick, 1961 Ritland, 1998 Mauriz et al., 2000
Eating disorders	Joy et al., 2016 Weiss and Hecht, 2016
Abdominal traumas	Koon et al., 2017 Johnson and Comstock, 2017

Light exercise reduces the risk of cancer in the large intestine (Bi and Triadafilopoulos, 2003). There is evidence that physical activity reduces the risk of colorectal cancer (Oliveria and Christos, 1997; Colditz et al., 1997; World Cancer Research Fund, 1997). In particular, physically active men and women are less likely to suffer from colorectal cancer, and the incidence is up to 50% less (Colditz et al., 1997).
Wannamethee et al (2001) studied a team of 7,500 men over 18 years and discovered a significant protective effect of physical activity on stomach cancer. It is necessary the exercise intensity to be moderate or high, to have the aforementioned effect. In a prospective study of 47,723 subjects aged 40 to 75 years, some factors were monitored, such as physical activity, body mass index, to identify the relationship between exercise and cancer. Finally, concluded that there is an inverse correlation between exercise and stomach cancer (Giovannucci et al., 1995). Despite the above studies resulting exercise and stomach cancer relationship, there are also some that did not show a reduction in risk, so the data is conflicting (Lee, 1994).

While earlier studies have yielded controversial results, subsequent studies have shown a protective effect of physical activity on cholelithiasis (Leitzmann et al., 1999; Leitzmann et al., 1998; Rissanen and Fogelholm, 1999).

Inflammatory bowel disease (IBD) is caused by immune dysfunction. It includes Crohn's Disease and ulcerative colitis. Patients with inflammatory bowel disease should be encouraged to take part in sports activities. (Bilski et al., 2014; Koon et al., 2017). The same conclusion is borne out by other research (Sonnenberg, 1990). Patients with inflammatory bowel should be active anyway, because there is a risk of muscle weakness and osteoporosis due to corticosteroids (Robinson et al., 1998). The above conclusion is also confirmed by a study, conducted in Germany, which correlated professions with inflammatory bowel disease. A lower incidence of disease was found in occupations, which implied greater physical activity (Sonnenberg, 1990).

Cheng et al. (2000) examined over 10,000 men and women to find the relationship between exercise and peptic ulcer. The study showed that moderate and high physical activity reduced the relative risk for duodenal ulcer in both men and women.

The relationship between physical activity and diverticular disease is the scope of some studies. In a prospective study 47,678 American men, 40-75 years of age, without diverticular disease, colon polyps, ulcerative colitis and cancer were observed for four years. During this period, 382 new cases of symptomatic diverticular disease occurred. Finally, physical activity was inversely associated with symptomatic diverticular disease (relative risk = 0.63) (Strate et al., 2009). A study showed that lack of exercise in women increased diverticular disease requiring hospitalization (Hjern et al., 2012). Another study concludes that physical activity alone or in combination with a diet high in fiber can be an important factor in preventing symptomatic diverticular disease. This is due to increase the activity of the colon through hormonal, vascular and mechanical ways, leading to reduction in food transit time (Aldoori et al., 1995).

Regarding liver disease classical literature shows that exercise has no effect (Schlang and Kirkpaptrick, 1961). Patients with liver disease appear to tolerate exercise without exacerbating liver function (Ritland, 1998). In the elderly, long-term exercise can improve the expected age-related decline in liver metabolism (Mauriz et al., 2000). In healthy individuals only exercise under extreme environmental conditions (e.g. high temperatures) can damage the liver.

Both men and women are more likely to develop eating disorders such as anorexia nervosa and bulimia nervosa than non-athletes (Joy et al., 2016). Athletes who compete in sports related to strength, aesthetics and weight and sports that emphasize low weight such as dancing, running and rowing, are at most risk (Weiss and Hecht, 2016).

The severity of Sports-related abdominal traumas varies from mild abdominal muscle contraction to a significant organ breakage and internal bleeding (Koon et al., 2017). The organs most affected are the spleen, the liver, the kidneys and the pancreas. In a survey conducted in schools, it was found that abdominal trauma from exercise is rare, but it can happen (Johnson and Comstock, 2017).

6 The role of nutrition

In a study conducted on triathletes, all participants who ate in less than 30 minutes from the start of swimming, vomit. Forty per cent of those who consumed a hypertonic drink had severe symptoms. All those who had intestinal cramps had consumed high fiber at the pre-exercise meal (Rehrer et al., 1992).

In another study, there is a correlation between carbohydrate intake and episodes of vomiting and flatulence but also between carbohydrate intake and higher performance (Pfeiffer et al., 2012).

A study with women concluded to the same results: significant gastrointestinal symptoms after a high carbohydrate intake (1.0 or 1.5 g / min) (Wallis et al., 2007).
According to Costa et al. (2017b) only one study has fully studied a protocol to prevent exercise-related disorders and symptoms. Taking for two weeks carbohydrates during daily exercise (2 to 1 ratio glucose to fructose or carbohydrate-rich food) reduced total discomfort and upper gastrointestinal symptoms by 40% (Costa et al. 2017b).
There is a large increase in the number of athletes who adopt gluten-free diet without a medical reason. Over 41% of them chose this option due to the belief it reduces symptoms and increases performance (Lis et al., 2015).

To avoid adverse symptoms from the gastrointestinal tract, certain dietary measures are proposed: Avoiding food rich in fiber and fructose and taking a lot of water to prevent dehydration (Oliveira et al., 2014).

7 Conclusions

Exercise undoubtedly has positive effects on health, especially in the cardiovascular system. However, negative effects are not uncommon and occur in different systems. Regarding the gastrointestinal system, as mentioned above, there are both negative and positive effects. Negative effects occur mainly in intensive and prolonged exercise. Athletes, coaches and doctors must have the proper knowledge to prevent and manage the condition the best possible way.

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