Today, most people know through advertising and education that a so-called healthier lifestyle including, among other things, increased physical exercise is beneficial. This holds true for many organ systems in the human body, but the effects on the gastrointestinal tract are not so clear cut [1]. Seemingly positive and negative effects of physical exercise on the gastrointestinal tract and possible underlying mechanisms will be discussed in this article.

Gastrointestinal symptoms during exercise
Gastrointestinal symptoms such as heartburn, chest pain, belching, nausea, vomiting, abdominal cramps, side ache and diarrhoea are reported by up to 50% of athletes during heavy exercise [2]. The occurrence of symptoms is related to the presence of gastrointestinal symptoms during non-exercise periods, age, gender, diet, training status and the mode of exercise [3]. The mechanisms behind these symptoms are far from clear, but reduced blood flow to the gastrointestinal tract, altered motility, increased mechanical bouncing, and neuroendocrine alterations have all been suggested [4].

Upper gastrointestinal tract
Symptoms proposed to be related to gastro-oesophageal reflux, such as heartburn and chest pain, are common in endurance athletes [2]. It has been shown that exercise can exacerbate reflux, depending on the mode of exercise and whether the subject recently had a meal [5]. However, in one recent study, reduced running-induced acid reflux by treatment with omeprazole was demonstrated, but heartburn, chest pain and regurgitation were not diminished [6]. To some extent, this finding speaks against the importance of acid reflux in the upper-gastrointestinal symptoms during heavy exercise. Other factors such as non-acid reflux, musculoskeletal problems and mechanical distension of the oesophagus from aerophagia may also be involved in the generation of these symptoms. Oesophageal dysmotility is also a plausible symptom-provoking factor, and oesophageal motility is affected by physical exercise.
This has been demonstrated in both trained [7] and non-trained athletes [8], where duration, amplitude and contraction frequency declined with increasing exercise. Another important aspect of chest pain during exercise, especially if the subject is middle-aged or older, is that pain of presumed oesophageal origin is often confused with angina pectoris, and vice versa. To complicate things further, acid in the oesophagus can induce myocardial ischaemia in patients with coronary heart disease [9].

Nausea, vomiting and belching also occur rather frequently after a bout of heavy exercise [3]. In the literature, these symptoms have been attributed largely to delayed gastric emptying. Although the existing results are somewhat conflicting, emptying of liquids and solids appears to be unchanged or accelerated at low exercise intensities, whereas high-intensity training delays gastric emptying [10]. However, the gastric acid secretory response to a meal is not affected by exercise [11]. Alterations in small-bowel motility may also be involved in these symptoms, and exercise affects the duodenojejunal postprandial motor activity but not the orocaecal transit time [12]. In this issue of EJGH, the active group from Utrecht demonstrates that strenuous exercise interrupts postprandial duodenal motility, decreases the number of activity fronts (phase III), and leads to gastrointestinal symptoms [13]. The mode of exercise was found to be of importance, since running suppressed phase III more than cycling did, probably due to mechanical factors. Moreover, the interruption of the postprandial motility pattern occurred much sooner after fluid supplementation with a carbohydrate sports drink during exercise than with tap water. Since glucose concentration is a well-known modulator of antroduodenal motility [14], the authors correlated blood glucose levels and phase III occurrence, but no such relationships were observed. This makes it unlikely that the glucose concentration per se explained the observed differences between the modes of supplementation. Unfortunately, no clear correlations were observed between alterations in motility and gastrointestinal symptoms, and the mode of exercise and supplementation did not affect the symptom profile.

**Lower gastrointestinal tract**

Altered function of the large and, to some extent, small bowls has been postulated as the cause of runners' diarrhoea [2]. As mentioned above, aberrant small-bowel motility has been observed during physical exercise, but with no clear effect on orocaecal transit time [12,13,15]. It seems logical that athletes suffering from diarrhoea after heavy exercise have accelerated colonic transit, given the fairly good correlation between colonic transit time and stool form [16]. Studies looking at colonic transit following physical exercise have shown accelerated [17] or unchanged [18] transit times. However, the exercise intensity in most studies has been moderate, making it hard to draw firm conclusions regarding a role in runners’ diarrhoea. A recent study on colonic motility using modern techniques with a solid-state catheter found that acute graded exercise, contrary to popular belief, decreased colonic motility [19]. During exercise, a decrease in phasic colonic motor activity was observed, but after exercise there was a preferential increase in the number and amplitude of propagating pressure waves and a decrease in the simultaneous and cyclical events. The authors speculate that the reduced phasic activity may offer less resistance to colonic flow and the increased propagating activity may propel stool, thereby possibly explaining the urge to defecate and diarrhoea after exercise. One must, however, be aware that in this study a short-lasting exercise period (3 × 15 min with 15 min rest between) was applied. Therefore, the possibility of generalizing these findings to, for instance, a marathon runner with problems with diarrhoea is not correct. Another conceivable explanation behind diarrhoea could be alterations in intestinal absorption, but Gisolfi et al. [20] did not find any influence of mild to severe cycle exercise on fluid or electrolyte absorption from the duodenojejunum. However, they demonstrated that, if electrolytes are included in the fluid supplementation during exercise, then carbohydrate should also be included to enhance fluid absorption.

The most dramatic problem during heavy exercise is the occurrence of gastrointestinal bleeding. During exercise, blood is shunted away from the gastrointestinal tract in favour of the skin and the working muscles. Therefore, gastrointestinal bleeding has been attributed mainly to ischaemia in the gastrointestinal tract, and both haemorrhagic gastritis and ischaemic colitis have been observed [2,4]. The risk for bleeding increases if the subject is dehydrated and hyperthermic. Importantly, this dramatic symptom may be prevented by regular fluid intake during exercise [21]. Also, the use of nonsteroidal anti-inflammatory drugs should be limited in endurance athletes to decrease the risk of gastrointestinal bleeding.

**Positive effects of physical exercise on gastrointestinal disorders and symptoms**

Today, there is clear evidence that physical activity reduces the risk for colon cancer [22]. According to the approximately 30 studies on this subject, inactive individuals have about a 1.2–3.6-fold increased risk of developing colon cancer as compared with active individuals. The proposed mechanisms behind this are changes in transit time allowing less contact time between cancer-promoting agents and the mucosa, but also indirectly affecting other factors related to cancer risk, such as the synthesis of prostaglandins and factors involved in immune function.
In two recent prospective studies, Leitzmann and co-workers [23,24] demonstrated a reduced risk for cholecystolithiasis in physically active subjects as compared with those with a sedentary lifestyle. They state for instance that 34% of cases of symptomatic gallstone disease in men could be prevented by increasing exercise to 30 min of endurance-type training five times per week. This inverse relationship between physical activity and gallstone disease was found to be independent of other risk factors such as obesity and reduced weight loss. The mechanisms by which exercise may influence gallstones are not clear. An effect on gallbladder function has been proposed, but no clear evidence for such an effect of exercise exists today [25].

Constipation is very common, and low physical activity has been found to be a risk factor for this troublesome symptom [26]. This symptom increases with increasing age, and in older subjects with constipation prolonged colonic transit time has been demonstrated [27]. Therefore, it seems logical to include physical training as one part of the treatment of chronic constipation, most probably acting through stimulatory effect on colonic transit [17]. In fact, this advice is probably what the majority of physicians give their patients with chronic constipation. Despite the sound theoretical basis, it has been difficult to demonstrate that increased physical activity as part of the management plan really reduces symptoms of constipation in otherwise healthy individuals [28]. However, in a geriatric population where constipation is very common and related strongly to inactivity [29], a positive effect of exercise on constipation and also related faecal incontinence has been observed [30]. Furthermore, physical activity in general and vigorous activity in particular also reduce the occurrence of colonic diverticular disease [31]. This is also thought to be mediated through accelerated colonic transit time.

Irritable bowel syndrome (IBS) affects about 15% of the population in Western countries. The role for exercise as a treatment modality in these patients is largely unknown. A recent study using questionnaires demonstrates that IBS patients who are active report fewer symptoms than those with a more sedentary lifestyle [32]. Moreover, in a study evaluating the effect of an educational class on health-promoting behaviours and symptoms in IBS, an inverse correlation was observed between pain and exercise [33]. A general improvement after 1 and 6 months after the end of the class was observed. However, the use of exercise as a possible treatment in IBS still needs to be evaluated further before general recommendations can be made.

Conclusion

Physical exercise affects the gastrointestinal tract in several ways. With heavy exercise, many gastrointestinal symptoms are seen. On the other hand, daily moderate physical activity reduces the risk for some gastrointestinal disorders and chronic gastrointestinal symptoms. These effects are probably mediated through, among other things, alterations in gastrointestinal blood flow and motility, but pure mechanical factors and neuroendocrine alterations may also be involved. More research within this field is needed, especially to explain the variability in the symptom pattern and relationship to different kinds of activities and intensity of exercise.

References