REVIEW ARTICLE

Lower limb vascular dysfunction in cyclists

Disfunções vasculares em membros inferiores de ciclistas

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Abstract
Sports-related vascular insufficiency affecting the lower limbs is uncommon, and early signs and symptoms can be confused with musculoskeletal injuries. This is also the case among professional cyclists, who are always at the threshold between endurance and excess training. The aim of this review was to analyze the occurrence of vascular disorders in the lower limbs of cyclists and to discuss possible etiologies. Eighty-five texts, including papers and books, published from 1950 to 2012, were used. According to the literature reviewed, some cyclists receive a late diagnosis of vascular dysfunction due to a lack of familiarity of the medical team with this type of dysfunction. Data revealed that a reduced blood flow in the external iliac artery, especially on the left, is much more common than in the femoral and popliteal arteries, and that vascular impairment is responsible for the occurrence of early fatigue and reduced performance in cycling.

Keywords: cycling; peripheral arteriopathy; blood flow; stenosis.

Resumo
O desenvolvimento de insuficiência vascular em membros inferiores relacionada à prática esportiva é incomum e no início do surgimento dos sinais e sintomas frequentemente pode ser confundida com lesão musculoesquelética, a exemplo de casos relatados em ciclistas profissionais, por estarem sempre no limiar entre o treinamento em nível máximo e o excesso de treinamento. O objetivo desta revisão de literatura foi analisar a ocorrência de disfunções vasculares em membros inferiores em ciclistas e as possíveis etiologias. Oitenta e cinco textos, entre artigos e livros publicados de 1950 a 2012 foram utilizados. Segundo a literatura, alguns ciclistas têm o diagnóstico de disfunção vascular realizado tardiamente devido à falta da familiaridade da equipe médica com esta modalidade de disfunção. Os resultados da pesquisa revelaram que a redução do fluxo sanguíneo na artéria ilíaca externa, em especial a esquerda, é bem mais comum que a da artéria femoral e poplítea, e que o comprometimento vascular é responsável pela ocorrência de fadiga precoce e redução do desempenho no ciclismo.

Palavras-chave: ciclismo; arteriopatia periférica; fluxo sanguíneo; estenose.

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INTRODUCTION

Bicycles are vehicles for human transport, and the number of bicycle users has greatly increased in the last decade. Cyclists that do not use bicycles for competition use them to exercise during their leisure time or to travel to work. Cyclists that use bicycles for purposes other than sports competition are less susceptible to lesions due to overload resulting from an inadequate posture on the bicycle. At the same time, professional cyclists are more likely to have musculoskeletal lesions as a result of working very close to the threshold between high level training and excess training, particularly when their posture on the bicycle and their training techniques are inadequate[1,2].

The numerous musculoskeletal dysfunctions associated with sports probably contribute to the underestimation of arteriopathy in the lower limbs of cyclists[3-6]. In the last twenty years, several cases of cyclists with vascular dysfunction in the lower limbs have been diagnosed. This condition may trigger exercise-induced pain, edema, loss of power and, consequently, a poorer performance[7-9], signs and symptoms previously associated exclusively with musculoskeletal lesions while the possibility of arterial insufficiency was overlooked[10,11].

This review investigated the occurrence of vascular dysfunctions of the lower limbs in cyclists, a topic of great importance in sports medicine, as healthcare professionals are not familiar with this type of dysfunction, which may lead to late diagnoses and, consequently, greater morbidity.

METHODS

A search was conducted in PubMed and ScienceDirect using the following keywords *in Portuguese, English and French: ciclismo, arteriopatia periférica, fluxo sanguíneo, estenose, cycling, peripheral arteriopathy, blood flow, stenosis, cyclisme, artériopathie périphérique, le flux sanguin, sténose.* Eighty-five texts, both articles and books, published from 1950 to 2012 were included in this review.

RESULTS

Thirty-nine original articles described lesions of the external iliac artery in cyclists; one, of the common iliac artery; seven, of the common femoral artery; one, of the superficial femoral artery; one, of the profound femoral artery; and six, of the popliteal artery. Table 1 shows that the lesions of the external iliac artery affected the left limb predominantly, which is in agreement with findings reported by Feugier and Chevalier[12].

Endofibrosis of the external iliac artery was found in cyclists that participated in road and mountain biking, as well as in time trial races (usually practiced by triathletes), at a total of 146 cases (Table 1) affecting 119 men (81.5%) and 27 women (18.5%). The distribution according to laterality and sex (men vs. women) was: 72 *vs.* 7, in left lower limb (54.1%); 31 *vs.* 11, in right lower limb (28.8%); and 16 *vs.* 9, bilaterally (17.1%). Results also showed that vascular dysfunction of larger vessels have become more common and not specific of any professional group or men sex, and that the lack of familiarity with the mechanism of common femoral artery lesion may explain the significant delay in the diagnosis of four in each six cases reported. Moreover, they also showed that the signs and symptoms of vascular lesions of the lower limbs usually include pain, claudication and early fatigue, especially during the practice of high-performance sports, which may be reproduced using maximal effort cycle ergometer tests and controlled with the ankle-brachial pressure index, whose mean value was below 0.49 for the cases with a diagnosis of endofibrosis of the external iliac artery.

DISCUSSION

Studies in the sports-related literature describe cases of blunt trauma in the common iliac[61], external iliac and common femoral arteries caused by the bicycle handlebar[61,62]. Although statistical data are not available to confirm the incidence of compression of the iliac artery secondary to cycling, Lim et al.[11] reported that arterial insufficiency may be responsible for 10% to 20% of the symptoms of pain and cramps resulting from claudication in professional cyclists. As symptoms may be overlooked, the delay in diagnosing endofibrosis of the iliac artery in competitive athletes, for example, is two years from symptoms onset, according to Lim et al.[11]. Until a diagnosis is made, the coaches of many cyclists often label them as lazy or unmotivated[63], which may force them to drop out of competition[3,11,16,21,23]. In fact, in a highly competitive sport, their blood supply is insufficient for their muscle activity demand[64].

Ankle-brachial pressure index

The ankle-brachial index (ABI) is determined by a test used to diagnose peripheral arterial occlusive

Table 1. Vascular dysfunction in lower limbs associated with cycling.

Author	Year	Vascular disease						Level	Age	Sex
		C.I.A.	E.I.A.	E.I.V.	C.F.A.	P.F.A.	P.A.			
Boyd and Jepson[13]	1950		●^{l}					Amateur	23	Men
Walder et al.[14]	1984		●^{r}					Professional	d. n. i.	Men
			●^{r}					Professional	d. n. i.	Men
Mosimann, Walder and Van Melle[15]	1985		●^{r}					Professional	23	Men
			●^{l}					Professional	24	Men
Chevalier et al.[3]	1986		●^{l}					Amateur and professional	23 to 31$^{\psi}$	Men
			●^{r}							
Pils et al.[16]	1990		●^{r}					Professional	28	Men
Rousselet et al.[17]	1990		●^{l,r}					Amateur and professional	22	Men
			●^{l}						23 to 47$^{\alpha}$	Men
			●^{r}						23 to 34$^{\beta}$	Men
			●^{l}						34	Women
Pillet et al.[18]	1992				●^{l}			Recreational	56	Men
Abraham et al.[19]	1993		●^{r}					Semiprofessional	20 to 49$^{\pi}$	Men
			●^{l}							
			●^{l,r}							
Cook et al.[20]	1995		●^{l}					Professional	45	Men
Hindryckx et al.[21]	1996		●^{r}					Professional	32	Men
Taylor et al.[22]	1997		●^{l}					Amateur	32	Men
Abraham, Chevalier and Saumet[23]	1997		●^{r}					Professional	22	Men
Brousse et al.[24]	1997		●^{r}					Amateur	49	Men
			●^{l,r}					Semiprofessional	53	Men
Wille et al.[25]	1998		●^{l}					Amateur	24	Men
			●^{l}						24	Men
			●^{l}		●^{l}				21	Men
			●^{r}						47	Men
Abraham et al.[26]	1999		●^{l}					Professional	18	Men
Speedy et al.[27]	2000		●^{l}					Professional	36	Men
Paraf et al.[5]	2000		●^{l,r}					Amateur	44	Men
Wijesinghe et al.[28]	2001		●^{r}					Professional	28	Women
Arko et al.[29]	2001		●^{l}					Professional	d. n. i.	Men
Kral et al.[30]	2002		●^{l,r}					Professional	24 to 37$^{\mu}$	Women
Sarfati et al.[31]	2002				●^{l}			Recreational	13	Men
					●^{l}			Recreational	9	Men
O'Ceallaigh et al.[32]	2002		●^{r}					Semiprofessional	34	Men
Teh et al.[33]	2003	●^{r}						Semiprofessional	60	Men
Bredt et al.[34]	2003				●^{r}			Recreational	14	Men
Sandri et al.[35]	2003				●^{l}			Recreational	23	Men
Scheerder, Schütte and Schnater[36]	2006		●^{l}					Amateur	26	Men
Shankar, Roskell and Darby[37]	2006		●^{l}					Amateur	30	Men
Takach et al.[38]	2006		●^{l}					Amateur	47	Men
Giannoukas et al.[39]	2006		●^{r}					Professional	25	Women
			●^{r}					Amateur	47	Men
Moore and Krabak[10]	2007						●^{r}	Recreational	59	Men
Korsten-Reck et al.[8]	2007		●^{l,r}					Professional	27	Women
Halena, Kwiatkowski and Znaniecki[40]	2007						●^{l}	Amateur	16	Men

C.I.A. common iliac artery; E.I.A.: external iliac artery; E.I.V.: external iliac vein; C.F.A.: common femoral artery; P.F.A.: profound femoral artery; P.A. popliteal artery; ^{l} left lower limb; ^{r} right lower limb; d. n. i. data not informed; $^{\psi}$ age of seven cyclists (2•^{r} and 5•^{l}) ranged from 23 to 31 years; $^{\alpha}$ age of sixteen cyclists ranged from 23 to 47 years; $^{\beta}$ age of five cyclists ranged from 23 to 34 years; $^{\pi}$ age of thirty-six cyclists (9•^{r}, 20•^{l} and 7•^{l,r}) ranged from 20 to 49 years; $^{\mu}$ age of four cyclists ranged from 24 to 37 years; $^{\gamma}$ of twenty-five cyclists included in the study, there were twenty-seven cases, as two cyclists (1 man and 1 woman) were studied at two different time points and in contralateral limb to the one affected before: 15•^{l}, ten men and five women - 8•^{r}, two men and six women, and 4•^{l,r}, three men and one woman.

Table 1. Continued...

Author	Year	Vascular disease						Level	Age	Sex
		C.I.A.	E.I.A.	E.I.V.	C.F.A.	P.F.A.	P.A.			
Carmo et al.[41]	2008		●^{r}					Semiprofessional	31	Women
							●^{r}	Amateur	44	Men
McAree et al.[42]	2008						●^{l,r}	Professional	33	Men
Venstermans et al.[43]	2009		●^{l}					Professional	25	Men
Willson et al.[44]	2010		●^{r}					Amateur	47	Men
Mathew et al.[45]	2010					●^{l}		Amateur	66	Men
						●^{r}		Semiprofessional	53	Men
Salam, Chung and Milner[46]	2010			●^{l}				Amateur	70	Men
Getzin and Silberman[9]	2010		●^{l}					Professional	32	Men
Vizcaíno et al.[47]	2010		●^{r}					Amateur	39	Men
Bucci, Ottaviani and Plagnol[48]	2011		●^{r}					Semiprofessional	38	Men
Gaughen Jr.[49]	2011		●^{l}					Amateur	27	Men
Barrett[50]	2011a		●^{r}					Amateur	37	Women
Weislo[51]	2011		●^{l}					Professional	28	Men
Aubrey[52]	2011		●^{l}					Professional	21	Men
Rezk and Drott[53]	2011		●^{l}					Professional	46	Men
Mughal, Rashid and Mavor[54]	2011				●^{l,r}			Amateur	59	Men
Bettega et al.[55]	2011						●^{l,r}	Amateur	18	Men
Politano et al.[56]	2011						●^{r}	Amateur	55	Men
Flors et al.[57]	2011		●^{l}					Semiprofessional	25	Men
			●^{l,r}					Professional	38	Women
			●^{l,r}					Amateur	36	Men
			●^{l,r}					Professional	26	Men
			●^{l,r}		●^{l,r}			Amateur	43	Women
			●^{l,r}					Professional	33	Men
			●^{l,r}					Semiprofessional	26	Women
					●^{l}			Amateur	39	Women
			●^{l}					Semiprofessional	55	Men
			●^{l}					Amateur	35	Women
Nakamura et al.[58]	2011		●^{l}	●^{l}				Amateur	57	Men
Sarlon-Bartoli et al.[59]	2012		●^{r}					Semiprofessional	56	Women
Politano et al.[60]	2012		15●^{l} 8●^{r} 4●^{l,r}					Professional	23 to 54	14 Men$^{\gamma}$ 11 Women$^{\gamma}$

C.I.A. common iliac artery; E.I.A.: external iliac artery; E.I.V.: external iliac vein; C.F.A.: common femoral artery; P.F.A.: profound femoral artery; P.A. popliteal artery; ^{l} left lower limb; ^{r} right lower limb; d. n. i. data not informed; $^{\psi}$ age of seven cyclists (2•^{r} and 5•^{l}) ranged from 23 to 31 years; $^{\alpha}$ age of sixteen cyclists ranged from 23 to 47 years; $^{\beta}$ age of five cyclists ranged from 23 to 34 years; $^{\pi}$ age of thirty-six cyclists (9•^{r}, 20•^{l} and 7•^{l,r}) ranged from 20 to 49 years; $^{\mu}$ age of four cyclists ranged from 24 to 37 years; $^{\gamma}$ of twenty-five cyclists included in the study, there were twenty-seven cases, as two cyclists (1 man and 1 woman) were studied at two different time points and in contralateral limb to the one affected before: 15•^{l}, ten men and five women - 8•^{r}, two men and six women, and 4•^{l,r}, three men and one woman.

disease (PAOD), and its normal value is greater than 0.9. The occurrence of a normal ABI value at rest does not rule out PAOD in cyclists[12,29,45]; therefore, this test should be performed at submaximal or maximal effort to induce the appearance of the complaints that result from cycling[3,30,65]. For cyclists, the effort test is more reliable when performed in a cycle ergometer or cycle simulator (absolute distance, or Strandness test in French) than when the treadmill test is used, because the ergometer and simulators reproduce the reality of cyclists during training or competitions more closely[7,9,12,66].

Placing the cuff while the patient is pedaling is difficult, and, therefore, blood pressure measurements are made immediately after the effort, at 30 seconds or in the first minute, while the patient is lying supine[67]. Figure 1 illustrates three blood pressure measurements in a cyclist immediately after the absolute distance test[66]. During the first three minutes, ABI in left lower limb falls, a hemodynamic result very different from that observed in the right lower

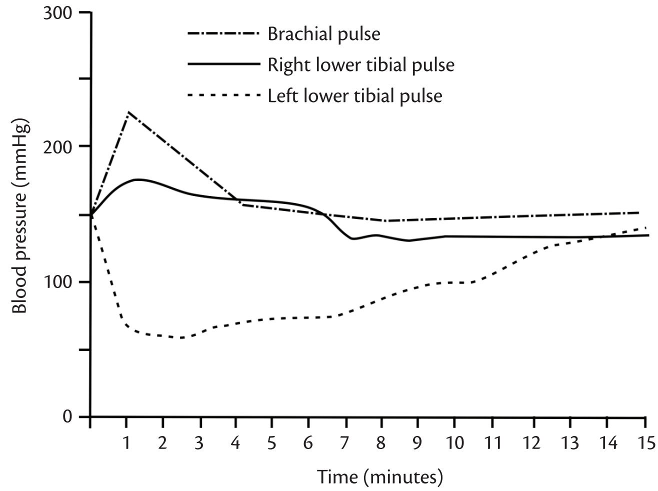

Figure 1. Peripheral blood pressure control in cyclist after effort test. Source: Adapted from Feugier[66], p. 354 (reproduced with permission from Professor Feugier).

limb. After a 12-minute rest, left ABI goes back to normal. The results of the Strandness test, associated with ABI < 0.5, are suggestive of lesion in the iliac, femoral or popliteal artery[66].

Failure in recognizing this type of vascular lesion may lead to the prescription of unspecific treatments for months or years and, consequently, unsuccessful results[7,10,21]. The lack of a specific and early diagnosis may often be explained by the fact that vascular lesions are mistaken or masked by musculoskeletal dysfunctions[5,8,10,15,21,22,27,38,59,64,68,] such as muscle strain[10], siciatica[23], low back pain[24] and compartment syndrome[27]. Treatment is, therefore, delayed, and the rehabilitation of the cyclist is complicated[26,27].

Speedy et al.[27] described a case of unspecific diagnosis and treatment. A triathlete presented with a seven-year history of exercise-induced pain in left lower limb. Initially, symptoms were limited to the anterior face of the leg, which led, two years later, to a diagnosis of compartment syndrome and to a fasciotomy, although the pressure in the compartments involved in the syndrome had not been evaluated. The procedure did not relieve symptoms. After uncountable diagnostic attempts, arteriography revealed endofibrosis in left iliac artery, which was then treated with endarterectomy.

Common iliac artery

Teh et al.[33] described the case of a 60-year-old cyclist with no history of cardiovascular dysfunction who presented with claudication in right lower limb in short-distance practices. Symptoms were first felt while he was riding up a steep hill and noted the sudden onset of pain in the right gluteal region, which progressed to the whole ipsilateral lower limb. The cyclist, then, stopped participating in competitions, sought medical care and received a diagnosis of right common iliac artery dissection extending to the common femoral artery. Initial treatment was the placement of a stent (14 x 64 mm) from the common iliac artery to the proximal external iliac artery. Postoperative angiography revealed persistent distal common femoral artery narrowing, but symptoms improved significantly. One month later, the cyclist again complained of claudication. An angiogram showed the same degree of lumen narrowing (ABI < 0.9), and the patient underwent endarterectomy of right common femoral artery, which eliminated the symptoms of arterial insufficiency in the limb.

External iliac artery

The first report of external iliac artery thrombosis in a cyclist was made by Boyd and Jepson[13] in 1950. In turn, Walder et al.[14] described the first case of external iliac artery stenosis due to endofibrosis in professional cyclists. Since then, several cases have been reported. According to some authors, arterial endofibrosis is a characteristic of the practice of high-performance endurance sports, such as triathlon and cycling[9,20,27,41,51,66,69.] According to Schep et al.[70], one of each five elite cyclists has an iliac artery blood flow limitation associated with the practice of sports. According to the medical literature, cycling has the largest number of cases of endofibrosis of the external iliac artery, and the left artery[12,44] is significantly more affected than the right[66].

Mean time for a cyclist to seek specialized medical care is three years from symptoms onset[15,27,48,58.] During this time, clinical signs and symptoms are often overlooked to avoid having to stop participating in sports. First, symptoms appear at submaximal effort[15], then at moderate effort and medium distance, and may later be reported to be felt during walks[13,48,54,59.] Among cyclists diagnosed with endofibrosis or thrombosis of the external iliac artery, annual training ranges from 5,000 km to 33,000 km[3,5,8,9,15,17,19,24,44,] and symptoms, according to case reports, may appear after distances reach 50,000 km to 380,000 km[9,17,32,44,48.]

External iliac artery dysfunction in cyclists is not often associated with PAOD characteristics, such as history of thromboembolic disease, abnormal cholesterol levels[30,45] and *diabetes*[30], which reinforces the hypotheses that its main etiological factor is the mechanical strain resulting from the posture on the bicycle, particularly aerodynamics[21], practice duration and training intensity[67]. According to Mosimann, Walder and Van Melle[15], the combination of high cardiac output and turbulent blood flow in the arteries during submaximal effort may be one of the causes of endofibrosis.

Tortuosity with kinking generated by hip hyperflexion[3,9,22,27-30,36,39,62,71] (Figure 2a, b) and artery compression due to psoas muscle and inguinal ligament hypertrophy during pedaling[3,27,29,36,39,61,71,72] are, according to the literature, the factors responsible for blood flow reductions. For this reason, the excision of this ligament is common in patients with vascular compression (e.g., external iliac and common femoral arteries) in the inguinal region[9,49,57,58,60.] According to Schep[63], artery tortuosity may be measured with an error margin of five degrees, and values range from 50 to 130 degrees.

During sports practice, cardiac output is higher. At submaximal or maximal effort, blood flow and blood pressure in the external iliac artery increase during systole, which increases the tension on the artery intima in the zones of tortuosity[7,65,72,73.] Tortuosity may also lead to artery stenosis and increase the collision of blood against the intima, which may result in lesions to the endothelium and induce an endofibrotic reaction[7,72].

The fixation of the external iliac artery to the psoas muscle using collateral branches (epigastric and circumflex arteries) associated with hip hyperflexion, common in an aerodynamic posture, favors the excessive extension of the artery[3,17,28,29,65,72-75] and increases vessel tortuosity when the hip is in a neutral position[3,12.] The increase in tortuosity may result from psoas muscle hypertrophy, which predisposes the artery to anterior displacement[72]. The hip hyperflexion test in symptomatic cyclists usually reveals a decrease of the pulse in the popliteal fossa[8,17] and contributes to the diagnosis when associated with imaging studies[9,23,24,43,57,60,] such as arteriography, CT angiography, digital subtraction angiography and magnetic resonance angiography.

Bender et al.[72] reported that the recruitment of the hip flexor muscles increased after the advent of the toe clips, which may contribute to psoas muscle hypertrophy[72,75.] Pils et al.[16] and Abraham, Chevalier and Saumet[23] described two cases of professional cyclists that stopped competing because of the pains and dysesthesia in right lower limb (dominant limb) under maximal effort. According to one of their patients, symptoms started three years before,

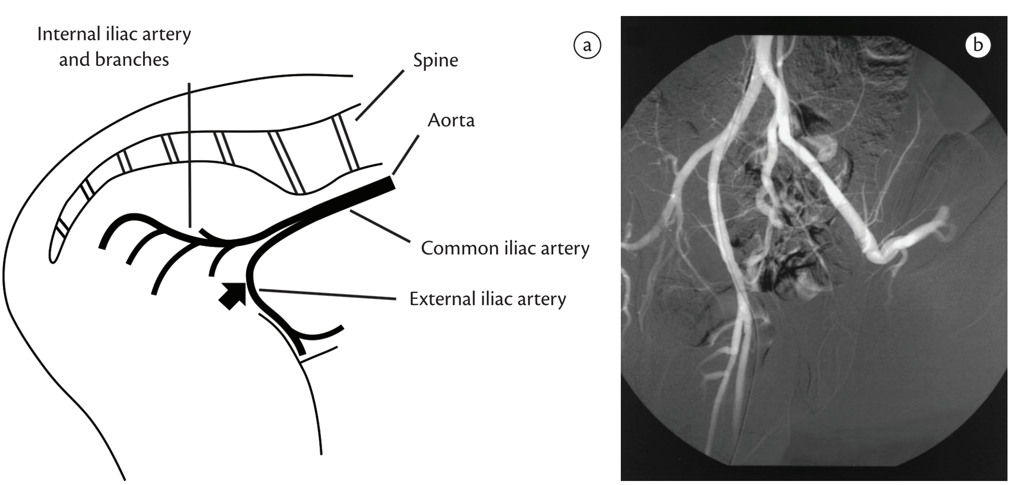

Figure 2. External iliac artery in aerodynamic posture: (a) without tortuosity or kinking; and (b) with kinking. Source: (a) Adapted from Lim et al.[11], p. 182; (b) Kral et al.[30], p. 567 (image reproduction authorized by publisher that holds copyright).

after replacing toe clips with clipless pedals (to use with cycling shoes), a change that, according to some authors, produces psoas muscle hypertrophy. Therefore, the performance of positive torque to pull up the pedal using the lower limb should be discouraged in the phase of recovery of the pedaling cycle (from 180 to 0 degrees, corresponding to the lowest and highest points, respectively)[72,75], because the contraction of the hypertrophied psoas muscle may lead to a significant reduction of blood flow in the external iliac artery[8,72.] Moreover, the asymmetry of the descending aorta, which lies to the left of the spine, is responsible for the unequal length of the common iliac arteries, but this anatomic characteristic has not been found to be an etiological factor in the literature[17,76].

Historically, the appearance of endofibrosis in the external iliac artery occurred at the same time as erythropoietin, a hormone known to elevate hematocrit, started being used by athletes[7,25]. Although the use of this drug significantly increases hematocrit, no connection has been made between its use and the development of arterial endofibrosis in cyclists, although it is known that users have an increase in blood viscosity, which may produce hemodynamic changes under high blood flow[7].

Stenosis due to endofibrosis of the intima reduces vessel lumen in 20% to 80%[3,5,8,17,23,25-27,41,66] (Figure 3a), in a segment 4 to 6 cm long[3,24,44,66] and 2 to 6 cm from the origin of the external iliac artery[38,66.] Figure 3b shows the histological findings in a case of marked stenosis (about 75% of the vessel lumen) in a cross-sectional segment.

Asymptomatic vascular dysfunction may compromise the performance of cyclists because of their high blood supply requirements[7,48]. Common signs and symptoms in cyclists with external iliac artery insufficiency are intermittent claudication, lower limb pain and edema, cramps, paresthesia, fatigue at submaximal or maximal effort, loss of power and poorer performance[9,22,26,28,30,48,70.] According to Chevalier et al.[3], when cyclists report the disappearance of symptoms after stopping exercising, the occurrence of peripheral vascular dysfunction should be suspected and investigated, because 60% of the suspected cases are diagnosed with vascular insufficiency, according to Schep et al.[70.] Fukui et al.[77] described the first case of claudication due to bilateral dissection of the external iliac artery, a vascular event in which ABI is also reduced during provocative testing.

Unilateral arterial insufficiency may induce musculoskeletal lesions due to the following mechanism: endofibrosis/thrombosis → stenosis → blood supply reduction → hypoxemia → early fatigue → asymmetrical use of force when pedaling → power loss → attempt to compensate using contralateral lower limb → overload to contralateral limb → musculoskeletal lesion[13]. This diagram shows that the occurrence of early fatigue is proportional to exercise intensity and degree of stenosis due to endofibrosis. According to Carpes et al.[78], the application of symmetrical force on the pedal optimizes performance. Moreover, asymmetry seems to be associated with the mechanisms of neuromuscular fatigue and with the adaptation to reduce the vulnerability to early fatigue or lesion[78,79].

To measure the efficiency of regular blood supply after endarterectomy in a cyclist with a diagnosis of endofibrosis of the external iliac artery, Korsten-Reck et al.[8] performed ergometric tests in the second month after operation and found that there was a significant improvement in cyclist performance without any workout to improve fitness before the

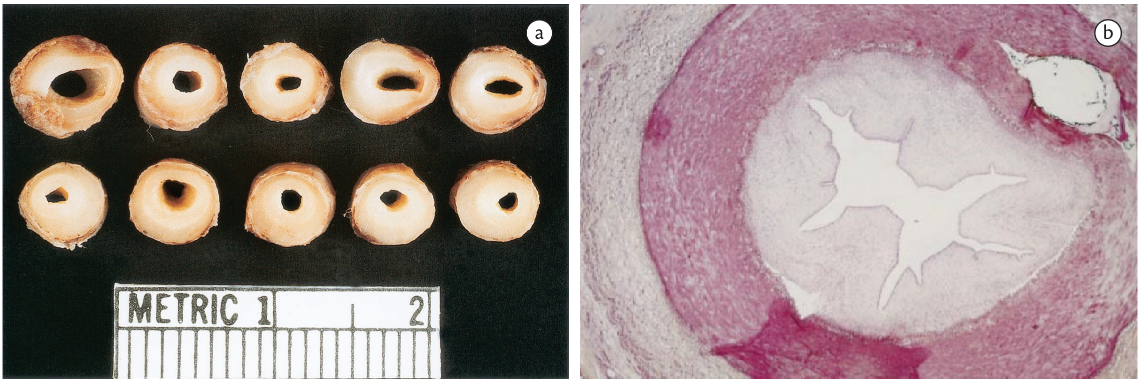

Figure 3. Dissected segment of external iliac artery in cyclists (cross-section) (a); Histology revealed stenosis of external iliac artery (b). Source: (a) Kral et al.[30], p. 569; (b) Abraham et al.[26], p. 1 (image reproduction authorized by publisher that holds copyright).

test. This finding was combined with a reduction in heart rate and anaerobic threshold.

According to Abraham, Chevalier and Saumet[23], this dysfunction may stabilize after training discontinuation, but it is important to consider whether cyclists should undergo surgical procedures if they plan to continue their careers in sports competition[3,23,25,44,60]. The recurrence among surgically treated arteries is lower than 10%[25,28,57,60]. However, bike fit is important in the attempt to find a trunk flexion that mitigates symptoms during cycling[9].

External iliac vein

Salam, Chung and Milner[46] described the first case of deep vein thrombosis due to stenosis of the external iliac vein. A cyclist sought medical care due to pain, edema and hyperemia in left lower limb after biking 291 km in three consecutive days. According to the authors, the lesion to the endothelium may have occurred due to the high venous flow or the trunk flexion associated with repetitive movements of flexion-extension of the hip joint, combined with vessel compression by the inguinal ligament. These mechanisms may convert the endothelium, usually antithrombogenic, into pro-thrombotic, and result in the production of a tissue factor, fibronectin, and the von Willebrand factor.

Common femoral artery

The common femoral artery has also been involved in lesions in cyclists, particularly due to acute trauma in the region of the femoral trigone (Scarpa's triangle), where this artery is more exposed[35,62,66]. The first case of common femoral artery lesion due to trauma with the handlebar end was described by Rich[80], and several other cases have been described in the literature since then. The common femoral artery is relatively immovable because it has multiple branches, periadventitial connective tissue and femoral sheath,[34] and this makes it vulnerable to compression against underlying bone structures[31]. According to Sarfati et al.[31], the artery may be damaged when the handlebar end hits the inguinal region, common in falls, as illustrated in Figure 4a. This type of trauma may lead to occlusion (Figure 4b).

Common signs and symptoms in cyclists with common femoral artery lesion due to acute trauma usually appear in 48 h with pain, local bruises, paresthesia, paleness, reduced or absent pulse and temperature significantly lower in the extremity of the affected lower limb when compared with the contralateral limb[31]. In young growing cyclists, lesions that are not diagnosed and treated may progress to chronic ischemia, compromising blood flow in the proximal growth plate of the femur, resulting in differences in length of lower limbs and changes in gait[31]. Surgical procedures should be a priority in cyclists with evident signs of ischemia, because the interruption of blood flow for more than 4 hours may lead to irreversible neurological damage and muscle necrosis[62].

Although arterial lesions due to handlebar trauma in the inguinal region are uncommon, they should be recognized by first aid professionals[35], because the lack of knowledge of this trauma mechanism is responsible for delayed diagnoses in four out of six cases reported in the literature[31].

Mughal, Rashid and Mavor[54] reported a case of common femoral artery lesion due to usual cycling.

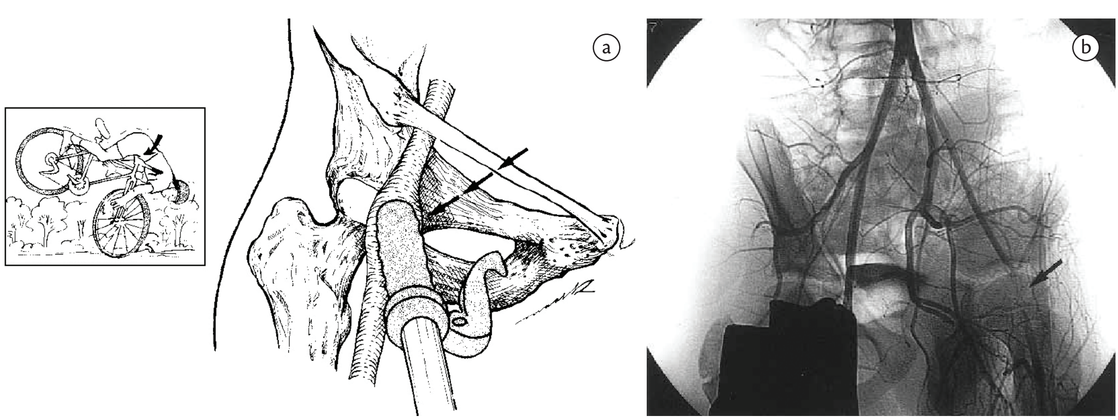

Figure 4. Mechanism of common femoral artery lesion by acute trauma: handlebar end compresses artery against femur head and pubic ramus (a). Arteriography shows occlusion of blood flow in left common femoral artery (b). Source: Sarfati et al.[31], p. 590 (reproduced with permission from Professor Sarfati and authorization from publisher that holds copyright).

A 59-year-old cyclist presented with a four-year history of cramps in both lower limbs during cycling, which improved after five minutes at rest. After endarterectomy to resolve stenosis, symptoms disappeared, but the cyclist was advised not to resume competing.

Popliteal artery

Popliteal artery entrapment syndrome, characterized by compression of the popliteal artery, has both an anatomic (congenital) and a functional (acquired) form[55,81,82.] It usually affects athletes that perform repetitive movements of the lower limbs, such as cyclists[42,62,66.] In the anatomic cases[55,83,] there is abnormal embryological development of the popliteal artery or the musculotendinous structures around it[55,83], which may lead to the formation of an aneurysm after stenosis, thromboembolism and arterial thrombosis[55,83,84]; In cases of the functional form, the artery is compressed due to the hypertrophy of neighboring muscles[55,83], a disabling condition that prevents participation in sports. Symptoms include claudication, paresthesia and muscle fatigue of the triceps surae during exercise, and are usually absent at rest[85].

Moore and Krabak[10] described an atypical case of a cyclist that complained of pain in the lateral face of the knee and in triceps surae of the right lower limb; pain onset was insidious, and it persisted for seven months. Initially, the diagnosis was gastrocnemius strain, and treatment was rest and physical therapy. Three months later, when the athlete resumed practicing, the pain recurred at a higher intensity. The cyclist was reassessed, and MRI revealed an aneurysm of the popliteal artery measuring 3.0 cm x 2.7 cm x 2.3 cm.

McAree et al.[42] also described the case of a cyclist with a popliteal artery lesion that presented with a five-month history of progressive claudication and difficulty in keeping performance due to pain in triceps surae. Physical examination revealed that ABI was 0.55 and 0.64 in left and right lower limbs, and MRI revealed a fibrous bundle in the popliteal fossa and bilateral hypertrophy of the medial head of the gastrocnemius muscle, which confirmed the diagnosis of popliteal artery entrapment syndrome.

Bettega et al.[55] described the case of a cyclist that presented with a two-year history of fatigue in the right calf and paresthesia when effort to pedal was greater. There was complete compression of the popliteal artery in both lower limbs at forced dorsal and plantar flexions. Preoperative arteriography showed bilateral medial deviation of popliteal arteries during forced dorsal flexion. After resection of the medial head of the gastrocnemius and release of the popliteal artery, intraoperative arteriography during dorsal flexion of the foot showed no compression.

CONCLUSIONS

The diagnosis of arterial insufficiency in cyclists has received growing attention in the last 20 years, and the number of publications discussing this topic has increased. The vessels most often affected are the external iliac, common femoral and popliteal arteries. Clinical signs and symptoms usually include pain and claudication during the practice of high-performance sports, a condition that may be reproduced during maximal effort tests using a cycle ergometer and be monitored using the ankle-brachial pressure index. Arteriopathy in lower limbs has been equivocally studied as a musculoskeletal dysfunction because of the little familiarity of sports medicine or related specialists with this type of dysfunction. Such lack of familiarity may result in unspecific diagnoses, prolonged inadequate treatments and, consequently, delayed rehabilitation. Peripheral vascular insufficiency is practically unknown by sports physical therapists and by professionals that work with cyclists, particularly those that adjust their bicycles.

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