EDUARD MISSONI, M.D, M.Sc.
TOMISLAV MLINARIĆ jr, B.Eng.
Fakultet prometnih znanosti,
Vukelićeva 4, Zagreb
IVO MLINARIĆ, M.D, D.Sc.
Hrvatski biciklistički savez,
Trg sportova 11, Zagreb

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THE ROLE OF CYCLING IN THE MODERN TRAFFIC, SPORT, RECREATION AND TOURISM

SUMMARY

More than 500 million bicycles have been estimated to participate nowadays in the modern road transport. Bicycles are the most numerous vehicles in the underdeveloped countries, whereas in the developed countries they are more frequently used for recreation and sport. Sudden revival of bicycle transport in modern times is likely to continue, at a higher or lower rate depending on the particular conditions in a certain country. The reason for this lies in the fact that bicycle is popular in underdeveloped countries because of its low cost, and in the developed countries it is preferred to motor vehicles because of its ecological, sport, and medical and recreational aspect.

The present slow development of cycling in Croatia, is the result of the war and post-war events, but this is expected to change towards rapid growth in free Croatia. This should be our tendency out of the same reasons which hold for the developed countries with special emphasis on tourism and environmental protection. Therefore, schoolchildren should be acquainted at schools with all the advantages of riding bicycles, they should learn how to ride a bike and all about the traffic rules. For normal bicycle traffic, an appropriate bicycle lane network should be constructed as soon as possible, for urban and suburban traffic, as well as bicycle lanes for recreational and tourist purposes. Moreover, the conditions should be created and cycling promoted with the sport and racing spirit, in which Croatia has always had a great and brilliant tradition.

1. PROBLEMS IN TERMINOLOGY

This type of vehicle with two wheels is called by the majority of peoples with names which suit their particular idiom. However, the most frequently used is the internationally accepted term of Latin - Greek origin, bicycle (*bi* meaning two and *kyklos* meaning the wheel).

The Americans[1] define a bicycle as a vehicle with two wheels in tandem one after the other, with a saddle-like seat. It is steered by handlebars and propelled by pedals or an engine and then it is called a motorcycle.

The French[2] use the terms *bicycle* or *vélocipede*, shortened *vélo*, for a vehicle with two wheels of different diameters, and *bicyclette* for a vehicle with two wheels of the same diameter.

The Germans use terms as *Fahrrad* or *Laufrad*, and the English *bicycle* or shortened *bike*.

In Croatia the most frequent term is *bicikl*[3] and it is defined as a lightweight vehicle with two wheels, for one person, with spokes, saddle-seat and chain transmission propelling the rear wheel by means of pedals. It can also be propelled by a lightweight engine. The bicycle for two persons is a *tandem*.

Rotim[4] defines a bicycle as a road vehicle with two wheels exclusively propelled by the rider's own power. The similarly designed vehicle, only with three wheels, is called a tricycle.

The Croatian dictionary[5] defines a bicycle as a vehicle with two wheels propelled by feet using pedals. The related nouns are *biciklist* and *biciklistkinja* meaning: a/ he or she who rides a bike, b/ the one who is riding a bike or was on a bike when something happened. The same dictionary gives the term *dvokolica* which would be more appropriate for the Croatian language, and is described as: a/ drawn wagon on two wheels (gig), b/ bicycle, c/ any vehicle with two wheels /on an axle or one behind the other/.

The Slovenes[6] use the term: *kolo* for the bicycle, and the related terms: *kolesar* (cyclist) , *kolesarstvo, kolesarjenje* (cycling).

In the past, the words *koturaš, koturaštvo* were used in Croatia, so that even one street in Zagreb has been named *Koturaška ulica.* The terms *bicikl, biciklist, biciklistički* and *biciklizam* have become common Croatian terms and they will be used until our linguists determine otherwise.

2. A SHORT HISTORY OF CYCLING IN THE WORLD

It is difficult to determine with accuracy when the development of bicycles as the means of transport started. One such vehicle is mentioned in the chronicle of the city of Meiningen as early as 1447. In the 1649 chronicle of the city of Nürnberg it was written that a certain blacksmith made a two-wheeled vehicle with which he managed to travel a distance of 2,000 feet in one hour. A watchmaker, S.Farfler, born in 1663, who was paralysed since childhood, designed for himself some kind of a tricycle for transport. A French physician, Richard made a two-wheeled vehicle propelled by feet, and there were also many more two-wheeled vehicles made of wood or iron, but since they proved useless in practice, they were soon forgotten. Moreover, when these started to be used in public transport as at the beginning of 18th century in Paris, the police banned them explaining that they frighten the horses and could cause traffic accidents[7]. To design a more practical vehicle using feet propulsion remained a great challenge and in 1769, a two-wheeled vehicle propelled by feet over the rear wheel appeared in England, and in 1791 in France, Comte de Sivrac designed a two-wheeled feet-propelled vehicle, but without the steering handlebars, and he called it *Célérifere*[8]. This vehicle consisted of two equal wheels fixed by a frame supporting a seat for the rider who moved forward by pushing himself along the ground with his feet.

A great leap in design development was made by a senior forester, Freiherr Karl von Drais. As early as 1811 he tried to propel a four-wheel cart by his feet, but failed. Then he designed a vehicle with two wheels, *Laufrad*, with the steering handle and travelled from Mannheim to Schwetzingen in less than an hour, which was four times faster than the postal carriage[9]. Because of this, but also because of other inventions, he was appointed professor of mechanics, and cycling was for the first time accepted as a lecturing subject at the academic level.

In 1839, in Great Britain, Kirkpatrick Macmillan made a vehicle with two wheels with a steering handle and propelled by pedals. In 1861, in France, Erneste Michaux, with the help of his son Pierre and assistant Lallement, improved a two-wheeled cart, and patented it under the name of *vélocipéde*. This bicycle with the steering wheel and pedal-propulsion positioned on a big front wheel, was later displayed at the 1867 Paris exhibition.

Such development in designing bicycles was also helped by the first bicycle race held in 1865 in Amiens, France, with five competitor cyclists. The track was 500 m long and the first to reach the finish line was Carignaux. Three years later the Michauxs founded in Paris the first bicycle club called "Velo club Paris". The first international bicycle race was held in 1869. The participants were French, English, and Danish amateurs.

The first bicycle propelled by pedals and with a chain transmission was designed in 1873 by H.J. Lawson in Great Britain, and in 1884, Thomas Stevens started on a trip around the world on a bicycle with a big front and small rear wheel.

The bicycle with equal wheels and direct steering was designed by J.K.Starley in Great Britain, and that same year Richard Weber in Germany designed a dynamo-light for bicycles. Pneumatic tyres for the wheels were invented by John Boyd Dunlop in 1888 (Great Britain), and the flexible brakes in 1900 by Frank Bowden (Great Britain).

These inventions paved the way to more comfortable and safer bicycle riding, not only for road traffic but also for sport, and since 1974 when Gary Fisher designed the "Mountain Bike", also for riding in the mountains and for the cycling tourism.

Due to the improved design ergometric solutions and the application of the increasingly strong and at the same time lighter materials, cycling is gaining popularity and the bicycle traffic is growing depending on their type and purpose, and this situation expressed in percentages in Great Britain looks as follows:[8]

– Mountain bicycles	38%
– Children's bicycles and tricycles	17%
– Action bicycles, BMX, etc.	17%
– Racing bicycles	8%
– City bicycles	7%
– Shoppers	7%
– Sport - touring bicycles	6%

3. A SHORT HISTORY OF CYCLING IN CROATIA

The first two-wheeled vehicle made of wood and called "derezina" probably after its inventor Karl Dreis, appeared in Croatia in 1865.[10] The first bicycles with high first wheel appeared in 1878 in Zagreb, Varaždin, Karlovac, Jastrebarsko, etc. but riding on them was not always pleasant and safe since the citizens often disapproved and attacked the cyclists and there were even occurrences of shooting and injuries. However, all this could not stop the development of bicycles in Croatia.

Not long after the founding of the first bicycle club in France, the "Croatian Cyclists' Association" was founded in Zagreb, in 1885, and in 1887 the Croatian "Sokol" founded its bicycle section "Klub biciklista Hrvatskog Sokola", with 30 members. They train regularly and go on excursions by bicycles 12-15 km around Zagreb, and later even further, all the way to Sisak. Cycling develops at an increasing rate, and in the last century Zagreb has two modern bicycle racetracks. New bicycle clubs are founded at that time in Zagreb, Karlovac, Varaždin, and in other places. In 1892, "Utrka za prvenstvo Kraljevinah Hrvatske, Slavonije i Dalmacije (Engl: Championship Race of the

Kingdom of Croatia, Slavonia, and Dalmatia) was held, and in the same year the first big international bicycle race took place in Zagreb, in which 13 bicycle clubs participated in front of about 3,000 spectators. Combined transport was organised in 1907 by train from Zagreb to Josipdol and then by bicycles to Plitvice.

During the World War I, organised cycling stagnates in Croatia, but already in 1919 it was revived and when the World War II started it had already become not only a sport branch but also a very important means of transport for going to work, school, shopping, and excursions. The tradition of bicycle races continues and many Croatian riders become winners, not only in Croatia but elsewhere as well. Such a situation in cycling remains after the World War II and in the then Yugoslavia the bicycles start to be manufactured which in turn reduces the price and increases the popularity of bicycles as means of transport.

4. THE CURRENT SITUATION IN CYCLING IN CROATIA

During the war from 1991 till 1995, Croatia fights for its existence suffering great damages to its material wealth including cycling. At the moment, many bicycle associations are being revived and founded and they then become members of the "Hrvatski biciklistički savez" (HBS - Engl: Croatian Cycling Federation), as a member of "Hrvatski olimpijski odbor" (HOO - Engl: Croatian Olympic Committee), and the Internacionalni biciklistički savez (UCI - Engl: International Cycling Federation). In 1996 HBS has 392 cyclists licensed (Figure 1). It is impossible to say exactly how many people in Croatia ride a bicycle, since the registration of bicycles is not obligatory. However, the fact that there is a growing interest for bicycles can be seen from the import, production and sale of the bicycles in Croatia. (Table 1). Here, of course, one should add

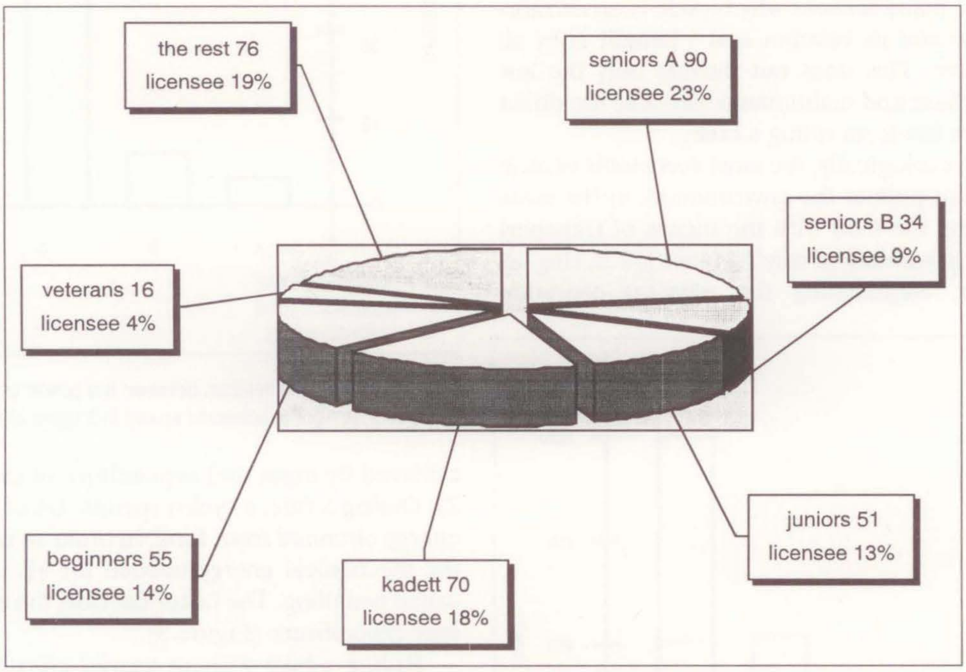

Figure 1 - Licenced in 1996.

Table 1 – The Traffic of Bicycles and Tricycles in Croatia

Import		1994		First 6 month of 1995	
		Bicycles	Tricycles	Bicycles	Tricycles
		72577		104795	
Sale	Limex, Donji Miholjac	3750	20955	5800	1929
	Big Toys, Labin	284		819	
Production	Limex, Donji Miholjac	3800	17949	7900	3903
	Big Toys, Labin	184		7942	

the existing bicycles as well as those imported by individuals without control.

Since Croatia belongs to the West-European civilisation region, it is to be expected that it will also with regard to cycling follow the appropriate trends. Germany can be used as an example, where in 1991 over 6 million bicycles were sold, and if we add the existing number of bicycles, then there are more than 60 million included in traffic.[11] Out of ten German families, eight are estimated to have at least one bicycle. In Austria 600,000 bicycles were sold at a time, out of which 40-50% were mountain and city bikes, 20% childrens', 12% trekking, 5% racing and others not specified. In Austria 30% of population rides a bike often in their free time, and 40% occasionally.

5. ADVANTAGES OF BICYCLES COMPARED TO OTHER ROAD VEHICLES

There are many reasons why bicycle is an extraordinary device and its relation cost - benefit is by all means positive. This does not include only the low price of purchase and maintenance but also the direct benefit a man has from riding a bike.

Bicycle is, ecologically, the most acceptable vehicle which does not pollute the environment, at the same time providing the man with the means of transport and with the possibility of staying in nature during his leisure time, emphasising the physical condition

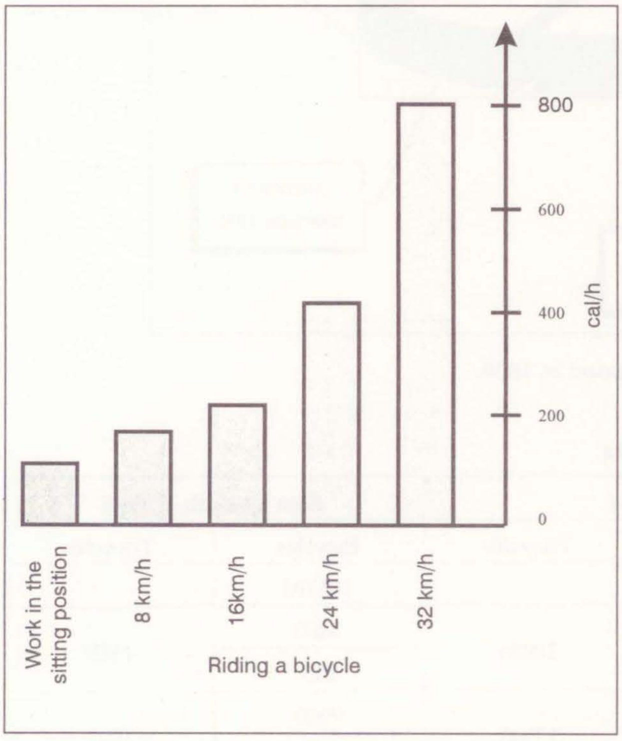

Figure 3

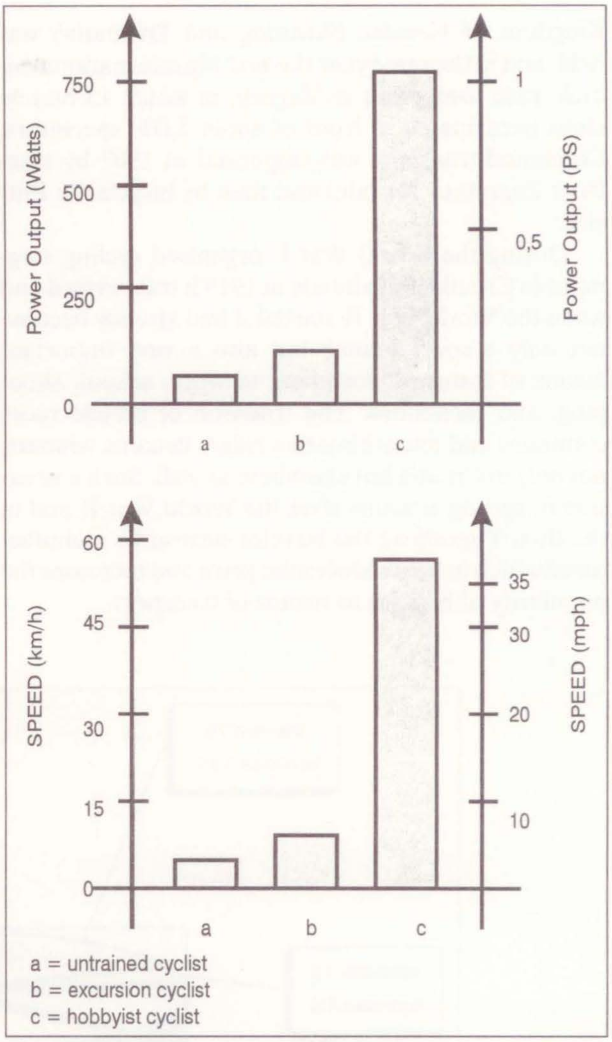

Figure 2 - the relation between the power output and the achieved speed in 3 types of cyclist

achieved by input and expenditure of energy (Figure 2). During a ride, a cyclist spends 1/4 of the chemical energy obtained from food, in order to convert it into the mechanical energy needed for his work, the so-called pedalling. The faster the ride, the higher the energy expenditure (Figure 3).

Riding a bike without special efforts in everyday life, does not demand any special diet, but for a sportsman cyclist, whether at training or at a race, the diet has to be rich in calories both regarding quantity and composition, since the expenditure of energy can be even up to 7-8,000 cal/day. In such cases, the preference lies on carbohydrates which are for the organism the most suitable source of energy (bread, pasta, potatoes, rice, fruit, vegetables, sugar). Fats in food are only an additional source of energy when the carbohydrate reserves are depleted, and proteins serve mainly for the growth and for supplementing the tissue and some secreted substances. The diet must contain also the adequate quantities of vitamins, minerals, and liquids except alcohol and other drugs or narcotics.

Therefore, cycling is a great support to the movement against addiction to alcohol, drugs, and smoking.

From the bio-mechanical aspect, bicycle is a vehicle which converts the rider's muscle power into the rolling energy of the wheels. By riding a bicycle the organism spends only 1/5 of the energy which would be needed to walk the same distance. The powerplant used in bicycle riding are the rider's legs which act on the principle of a lever. Moving starts by contracting and extending of the leg muscles, which then initiate adequate movements in the joints, which are then by turning of the pedals transferred further to the wheels. This means that co-ordinated motion of the joint-muscular system is of utmost importance. Here, two kinds of muscle fibres need to be distinguished. Red fibres contract slowly, contain a lot of oxygen and therefore they are very important for the so-called aerobic muscular activity. White fibres contract faster and they are important for the start and fast cycling, but their efficiency is short since they tire quickly due to the lack of oxygen. This relation between muscle fibres and oxygen reserves is genetically conditioned, but it can be influenced to some extent by appropriate exercises.

Ergonomics, a science dealing with the study of the relation between man, machine and environment, can be applied in cycling in order to improve the economy of riding a bike. Complexity of movements, keeping the balance, and observing the environment require a whole range of co-ordinated skeletal-joint-muscular movements. In analysing this system it should be considered that this is a group of one closed kinematic chain (spine and thorax) and five open chains (head, arms, legs). The freedom of movement provided by the system of joints, as suggested by Croatian experts[12] can be expressed in 250 degrees as follows:

- 95 joints with one degree,
- 80 joints with two degrees,
- 75 joints with three degrees.

The arm with the shoulder joint would have 28, and the leg 25 degrees. The flexibility of certain joints does not depend only on their structure but also on the number and type of muscles that provide movement, and in riding a bike the movement of the most important lever, and that is the thigh-bone, 20 muscles are active. In the evaluation of biomechanical and bioelectrical parameters involved in the motion of the considered kinematic pair or chain, the integrated value of the electromyogram (EMG) which is used to measure the electrical activity in the muscle, depends mainly on the amount of active muscle fibres involved in the movement as well as on the factors which are caused by the measurement. If these factors were excluded, the measured values would be compared to the maximum electrical activity which would occur if all the muscle fibres were activated.

The efficiency in one joint caused by contraction of one muscle and movement in one plane can be expressed as follows:

$$M_i = a_i \frac{U_i(\alpha)SL}{U_{i\max} S_o L_o} \gamma_i(\alpha)$$

where:

U_i – is the integrated EMG value of the muscle for a certain position of angle α,

$U_{i\max}$ – is the value of maximum electrical activity that would occur if all the fibres of the muscle were activated,

SL – is the relation between forces and the length of the muscle in a certain activity,

S_oL_o – for the same muscle without dimension,

γ_i – is the arm of the force of this muscle,

M – is the angle of rotation of the kinematic pair,

a_i – constant co-operation coefficient determined from the appropriate operating conditions of a combination of forces M_i.

As the actual movement in riding a bike is physical, it can be better determined by the co-operation of all the muscles or by the direct stimulus of the whole leg. When all the parameters involved in such a movement are determined, this synergetic action can be mathematically expressed as follows:

$$M_e = \sum_{i=1}^{n} a_i \frac{U_i(\alpha)S_i L_i}{U_{i\max} S_o L_o} \gamma_i(\alpha)$$

The basic scheme of the man - machine system, where the concept of biological condition includes the expressed notions and ideas, is presented in Figure 4.

The muscle-joint-bone movements of legs are transferred to the bicycle pedals A-B and from there over the chain to the rear wheel D which then due to the ground friction propels the bicycle (Figure 5)[4].

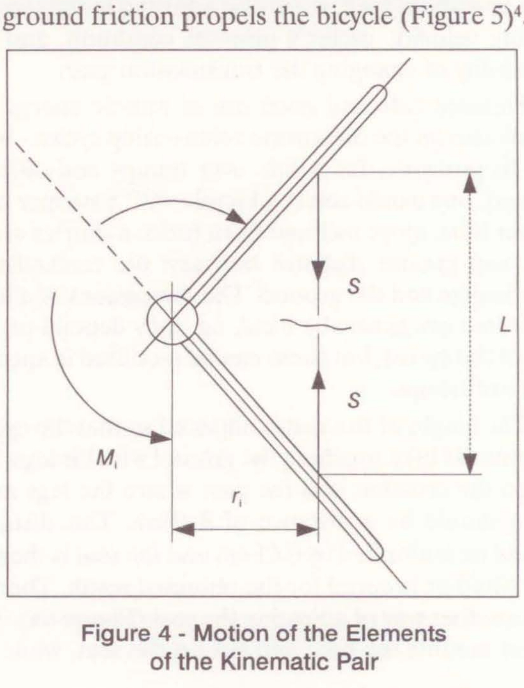

Figure 4 - Motion of the Elements of the Kinematic Pair

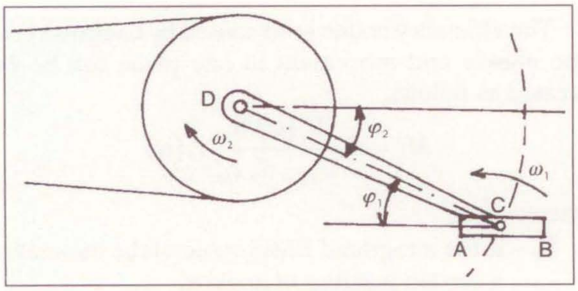

Figure 5 - A Scheme of the Bicycle Transmission Mechanism Operated by Pedals

Since the pedal rotates within a certain time at relative speed ω_1 in relation to lever C-D for the angle φ_1, within the same time the lever rotates for the angle φ_2 at its transmission rotation at an angle speed ω_2. As the rotation angles are equal ($\varphi_1=\varphi_2$), the angle speeds $\omega_1=\omega_2$ of the relative and transmission rotation movement are equal, and this kinematic relation can be replaced by the translational movement velocity $V=\text{CD}\,\omega$.

It should be, however, stressed that riding a bicycle does not include only the transmission energy of the rider's muscle power, but also the gravitation , inertia, centrifugal forces, friction between the wheels and the ground, direction and strength of the wind, as well as some other minor factors. Therefore, in operating the pedals, the rider's legs act as a flywheel which, using the inertia force pushes the pedals through idle stroke, using the divergent position of pedals, so that while one pedal is pushed downwards the other one goes up. Here, it is important, and this is recommended by experienced cyclists[13], that the idle stroke is reduced by pedalling as much as possible, and the pressure on the pedals needs to be even and the number of rotations with or without load, should be adjusted to the terrain, cycling velocity, cyclist's physical condition, and the possibility of changing the transmission gear.

Pleasant ride and good use of muscle energy depends also on the dimension relationship cyclist - bicycle. In principle, for a ride over bumpy and difficult ground, one would select a bicycle with a steeper handlebar tube, more inclined front forks, a shorter crossbar, and greater distance between the transmission mechanism and the ground. The dimensions of a bicycle frame are generally fixed, i.e. they depend on the age of the cyclist, but these can be modified in specialised workshops.

The height of the seat is adjusted so that the cyclist mounts the bike touching the ground with his legs. Between the crossbar and the part where the legs meet there should be a distance of 8-10cm. This distance should be multiplied by 0.61 cm and the seat is then either lifted or lowered for the obtained result. There is also another way of adjusting the seat (Figure 6a). The cyclist mounts the bike and sits on the seat, while his extended leg rests with the foot on the pedal at its lowest point. The length of the distance between the seat and the handlebars is measured by the length of the forearm (Figure 6b).

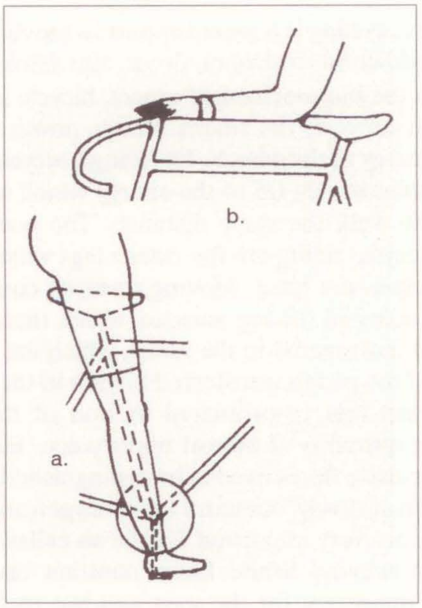

Figure 6a

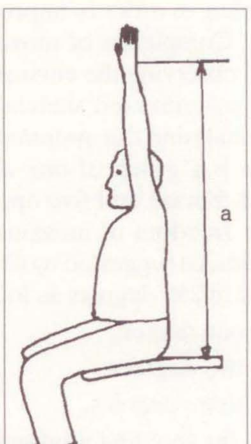

Figure 6b - Determining the Length of the Bicycle Crossbar

6. SAFETY PRECAUTIONS IN CYCLING

With the increase in road traffic, the danger for the cyclists on the roads grew more and more. Therefore, already in 1931, at the 44th annual conference of the "Croatian Bicycle Club Sokol", in Zagreb, the representative from the Police Department, Mr. Obertinski, the senior inspector, explained the road-police regulations and presented a scheme of traffic in the city.[7] He further stated that the cyclist members of the bicycle clubs had the fewest traffic accidents unlike the so-called illegal cyclists who came second by the number of accidents. This proves that it was clear already in the beginning of the motorised road traffic that it will complicate the safety conditions and that certain measures need to be undertaken in order to reduce the road accidents. To what extent had these measures been carried out and how successful these were, can be seen in the statistical data for Croatia about the injured (Table 2a) and the number of fatalities (Table 2b). These data are not complete since it was impossible to get the data for the whole territory of Croatia, especially during the war and even now, but the ones presented give a clear picture that the numbers give cause to worry and that these problems should be solved with more determination and more efficiency. In doing this, the causes of traffic accidents involving cyclists can be divided into subjective and objective ones. The subjective causes can be attributed to poor bicycle riding technique and misreading the traffic signs.

7. SUBJECTIVE PROBLEMS IN CYCLING SAFETY

It is not difficult to learn to ride a bicycle. The essential thing is to know how to keep the balance and there are three ways in learning how to do it. During learning, one can add one smaller wheel to the rear wheel in order to increase stability. Another way is for the teacher to hold the seat and run after the bicycle while the learner is turning the pedals. The critical moment is when the teacher lets go, since this usually results in the loss of balance and fall. The third, and safest way is for the learner to sit on the bicycle without pedals, with the seat adjusted so that he can reach the ground by his feet and by pushing forward move and learn how to keep the balance.

Stable balance is reached when the vertical through the body centre of mass passes within the support polygon (Figure 7).[4] If the vertical line passes along the border of the polygon, the body is in unstable balance. The problem with bicycles lies in the fact that the contact surface between the wheels and the

Table 2a – Injured (drivers, passengers and pedestrians in Croatia)

Year	Bicycle		Motorcycle		Moped		Passenger Car		Pedestrians
	drivers	passengers	drivers	passengers	drivers	passengers	drivers	passengers	
1988	1204	27	855	259	957	120	5364	5527	3333
1989	1145	31	770	200	870	112	5701	5637	3149
1990	1120	16	793	211	872	134	6189	6092	3162
1991	783	12	671	205	656	96	5388	4635	2491
1992	996	13	651	183	723	105	5539	5077	3004
1993	911	17	677	153	366	47	4940	4554	2823
1994	1043	18	892	189	357	43	5247	5219	3026
1995	1017	–	1002	–	657	–	11153	–	2684

Table 2b – Fatalities (drivers, passengers and pedestrians in Croatia)

Year	Bicycle		Motorcycle		Moped		Passenger Car		Pedestrians
	drivers	passengers	drivers	passengers	drivers	passengers	drivers	passengers	
1988	122	–	61	14	35	6	304	269	371
1989	105	–	38	10	41	1	354	286	351
1990	120	–	44	9	33	1	354	299	379
1991	80	–	30	8	31	2	280	230	268
1992	88	2	25	3	30	2	241	163	306
1993	70	1	25	5	12	2	234	175	234
1994	72	1	25	5	9	–	211	158	250
1995	53	–	38	–	18	–	399	–	234

In 1995 a new Bulletin on the road traffic safety was issued and there were no data about passengers, so they were probably included into the 1995 data.

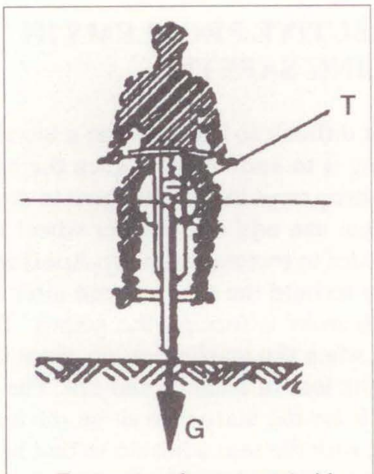

Figure 7 - The Cyclist and the Vehicle in Stable Balance

ground is very narrow, like a little wider line. Therefore, the rider and the bicycle are in unstable balance while being in a completely vertical position, and any inclination leads to the loss of balance since then the vertical through the centre of mass exits the connecting line of contact between the wheels and the ground, and this results in fall (Figure 9).

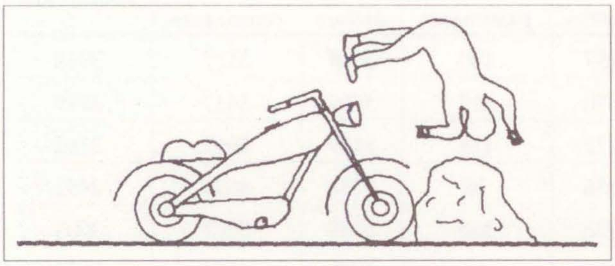

Figure 9 - Effect of Inertia Force Caused by Impact With a Solid Obstacle

Trying to reduce the distance d and to keep the balance, the rider balances on the bicycle and this occurs most often when negotiating a curve, at the beginning of the ride, in slowing down, and at the end of the ride. These moments require special attention because of the possibility of falling over, or colliding with another passing vehicle. In riding, the wheels of the bicycle rotate behaving like tops and resist the change of position of their axles. Therefore, when the rider and the bicycle incline to one side the centre of gravity will act on the front wheel to turn to the same side when the handlebar is free. If the ride continues in that direction of turning, centrifugal force acts opposite to the gravity. Therefore, the bicycle will start to return to the vertical position and to the straight path.

In passing a curve, the rider has to neutralise the action of the centrifugal force by inclining the bicycle towards the centre of turning, so that it would not di-

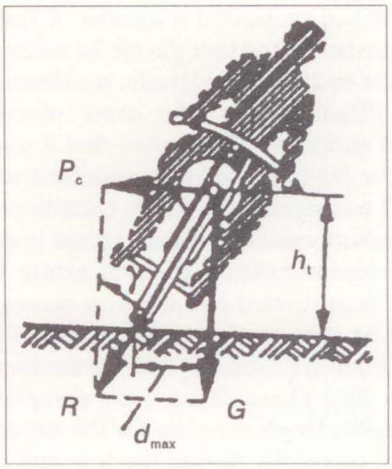

Figure 8 - Riding a Bicycle in a Curve

rect the bicycle in the opposite direction. In passing a curve of radius R round the turning point O, there is the centrifugal force $F_c = M \cdot a_n$. Here, $M=$ the mass of the bicycle and rider, $a_n = V^2/R$, $V=$ velocity of the bicycle. To avoid turning over because of the moment $F_c \cdot h_t$ of the centrifugal force, the rider needs to incline the bicycle towards the turning centre for the angle γ, thus achieving the balance $F_c \cdot h_t = -G \cdot d_{max}$ (Figure 8)[4].

Here, d is the distance between the projection of the centre of mass of the bicycle and the rider on the ground surface and contact point of wheel ground rolling. The angle of the required inclination is obtained from the following formula:

$$\mathrm{tg}\,\gamma = F_c/G = V^2/gR$$

Therefore, it can be concluded, the higher the speed and the smaller the radius of the curve, the greater the inclination of the bicycle, where the inclination does not depend on the mass of the rider and the bicycle.

If the centrifugal force is greater than the friction of the wheels, the rear wheel starts to skid in the direction perpendicular to the riding direction, and this results in the fall of the rider and the bicycle. Here, the friction is $G\mu_b$, where μ_b is the coefficient of lateral friction and in relation to the centrifugal force, the greater the angle of inclination, the smaller the coefficient of lateral friction. If γ_{gr} = the limiting angle in rear wheel skidding, then the following equation holds:

$$\mu_m = V^2/gR.$$

In order to avoid skidding, the turning radius at a given velocity V should not be less than $R_{min} = V^2/\mu_b g$. This means that the turning radius depends on the velocity, type and condition of the ground, and the limiting velocities that in a curve could cause a fall on the road without a gradient can be expressed as follows:[12]

$$V_{prv} = 3{,}6\sqrt{\frac{d_{max}\, g\, R}{h_t}} \quad [\mathrm{km/h}]$$

Therefore, if $d_{max}/h_t > \mu_b$ the bicycle swerves, and in the contrary case it turns over without previous swerving.

For overturning in a curve, braking is especially dangerous and should be carried out with special attention. Braking with the front brakes should be avoided to prevent the wheel-blocking, but any sudden braking at a greater speed by inertia force can throw the rider over the handlebars of the bicycle. Similar thing happens when the bicycle hits at high speed a solid object causing the rider to fall and injuring most frequently the head, as with motorists (Figure 9).[14]

Because of such injuries cyclists should wear bicycle crash helmets, although these are not fully approved of, and there are still certain professional cyclists who do not wear them while racing.[15]

Safety of riding a bicycle depends to a great extent on the brakes, their correct functioning, and the way of braking. According to the public traffic regulations, bicycles need to be fitted with two separate brakes, except track racing bicycles, but these are not allowed in public traffic. For the rider's own safety and for the safety of other traffic participants, the slowing down or coming to a stop should start by slowly pressing the rear brake, and then gradually by the front brake as well. Modern bicycles have both hand brakes which in braking act on the wheel rim and not on the tyre. There are five types of brakes, three of which act by pulling the wire activated by pressing the handle on the handlebar grip, and the other two are somewhat more complicated since these are hydraulic brakes and motorcycle type disc brakes. All these types of brakes are good provided they are maintained regularly. At a velocity of 20-30 km/h and a clean and dry asphalt road, the activating of the rear brakes only, slowing down is on average 2.0-2.8 m/s^2, of the front brakes it is 1.0-1.8 m/s^2, and if both brakes are activated, it is 2.5-3.0 m/s^2.

For public traffic safety reasons, only persons above the age of 14 can ride a bicycle on the roads.[4] Younger persons, e.g. schoolchildren can also ride a bicycle if they have passed the bicycle riding test included in the subject of traffic education at school. Also, a child of eight can ride a bicycle but only accompanied by a person above the age of 16. One can ride a bicycle on all roads if not prohibited by a special sign, and excluding motorways and motor roads (reserved for traffic of motor vehicles only). While riding the rider has to adjust the velocity to the properties and condition of the road, visibility, atmospheric conditions, traffic density, condition and loading of the bicycle, and his or her physical condition, taking into consideration the ability to stop or change the direction with previous observation of the surrounding and giving the appropriate signals.

Riding a bicycle in gloomy weather, as well as from twilight to dawn, requires the lights to be switched on and adjusted so that it illuminates the road in the range from 10 to maximum 50 metres. On the rear and on the pedals the bike should be fitted with reflectors (catadioptric lights). When riding in severe conditions and with visibility of about 15 m, and the reaction speed of 1 s, for the sake of safe braking, the velocity should not exceed 19 km/h.

8. OBJECTIVE PROBLEMS IN CYCLING SAFETY

Modern road traffic has provided people with greater mobility but has also endangered their health and lives. Environmental pollution, noise and nervous stresses, and in addition, numerous traffic accidents bring a lot of evil not only to people but to the whole living world. Surely, viewed from this aspect, cycling is the least dangerous. Danger starts when bicycle riders get increasingly restricted in traffic by being pushed and threatened by far more aggressive motor vehicle drivers. These cycling problems have been specially dealt with in the "Kölner Protokol '89 zum Radverkehr" - Heft No.30. Among other issues, it demands elimination of contrariness in priority of individual motorised traffic regarding pedestrians and bicycle riders. The aim is to improve the safety of these two weaker groups, creating preconditions for faster and safer bicycle traffic. This means constructing special paths, lanes, and corridors for bicycle riders, as well as parking lots protected from rain and theft. This has been accepted as priority in some towns as e.g. in Erlangen (Germany), where 175 km of cycling lanes have already been constructed.14 In towns where there are no possibilities of constructing separate cycling lanes, bicycle traffic can pass through streets less busy with motor vehicle traffic, as well as in one way streets, with specially marked lanes for their passage. These lanes should be at least 1.5 m wide. Specially dangerous for the cyclists are street crossings, and for their protection it is recommended to construct areas (pre-crossings) where they could stop for a while, observe traffic, give a signal, and then safely take a turn.

Riding a bicycle on pedestrian paths is allowed but the pedestrians are reluctant in accepting this since their space for living in cities is small anyway, and the sudden and often noiseless approach of bicycles makes them nervous and poses a threat. There is also an objection to excursion cycling causing environmental pollution by negligence and driving away small and large animals especially at sunset, and by treading on and damaging flora which recovers with difficulty especially in mountains. Therefore, organised group bicycle tourism is preferred, controlled by a guide and in combined transport to the excursion destination. Thus, e.g. 62% of bicyclists come to Isartal in Bavaria carrying their bicycles on the roofs of their cars and for the ride along the Danube 53% of bicyclists travel first by train (Radtramper "Wien-Passau").

9. CONCLUSION

For a tourist country such as Croatia which has all the preconditions fulfilled, it would be of special significance to provide all the safety conditions for the development of cycling as a means of transport which is most environmentally friendly. For the development of tourist cycling in Croatia, there are ideal conditions both for riding during week-ends and during holidays. Therefore, cycling lanes should be constructed as soon as possible in towns and suburbs, and signals set and cycling paths controlled and maintained for the mountain recreation tourism.

The promotion for all kinds of cycling can be best devised by organised sport cycling with appropriate races of local, national and international character. In order to develop this kind of sport as soon as possible, to reach and surpass the traditions already achieved by this sport in Croatia, greater support should be given the HBS (Croatian Cycling Federation) and to other clubs in educating young cyclists, as well as in organising and promoting the cycling competitions.

SAŽETAK

ULOGA BICIKLIZMA U SUVREMENOM PROMETU, SPORTU, REKREACIJI I TURIZMU

Procijenjuje se da u suvremenom cestovnom prometu sada ima preko 500 milijuna bicikala. Bicikl je najbrojnije prometno vozilo u nerazvijenim zemljama dok se on u razvijenim zemljama najčešće koristi u svrhu rekreacije i sporta. naglo oživljavanje biciklističkog prometa u novije doba ima tendenciju da se i dalje nastavi, brže ili sporije, ovisno o uvjetima u pojedinim zemljama. Razlog je u tome što je bicikl omiljen u nerazvijenim zemljama zbog niske cijene koštanja, a u razvijenim je zemljama u prednosti pred motornim vozilima u ekološkom sportskom i zdravstveno-rekreacijskom pogledu. Sadašnji usporeni rast biciklizma u Hrvatskoj treba pripisati ratnim i poratnim zbivanjima, ali je očekivati da će u slobodnoj Hrvatskoj on brzo zauzeti uzlaznu krivulju. Tome trebamo težiti iz istih razloga koji vrijede za razvijene zemlje s posebnim naglaskom na turizam i zaštitu okoliša. S tim u svezi bilo bi potrebito u školama upoznati đake sa svim prednostima biciklizma, omogućiti da nauče voziti bicikl i upoznaju pravila ponašanja u prometu. Za normalno odvijanje biciklističkog prometa bitno bi bilo što prije izgraditi odgovarajuću mrežu biciklističkih putova za gradski i prigradski promet kao i biciklističke staze za rekreativce i turiste. Osim toga bilo bi potrebno stvoriti uvjete i popularizirati biciklizam u sportsko-natjecateljskom duhu gdje je Hrvatska i do sada imala veliku i slavnu tradiciju.

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