TRIATHLON-RESEARCH.com
INNOVATIVE KNOWLEDGE INTO PRACTICAL MEASURES

Institute of Sports Science, Karl-Franzens-University Graz

UNI GRAZ

Injuries and Pain in Long Distance Triathlon

Correlation between training-related risk factors and frequent discomforts among long distance triathletes

MMag. Dr. David Hoeden

Overview:

- ***General information*** *(training, technique, material …)*
- ***Injuries*** *(swim, bike, run)*
- ***Problems & challenges*** *(literature …)*
- ***Dietary supplement*** *(ranking, dose, reason …)*

TRIATHLON-RESEARCH.com
INNOVATIVE KNOWLEDGE INTO PRACTICAL MEASURES

Outline:

Multisports
Cross(triathlon)
Cross(duathlon)
Wintertriathlon
Aquathlon
Polyathlon
Gigathlon
Quadrathlon …

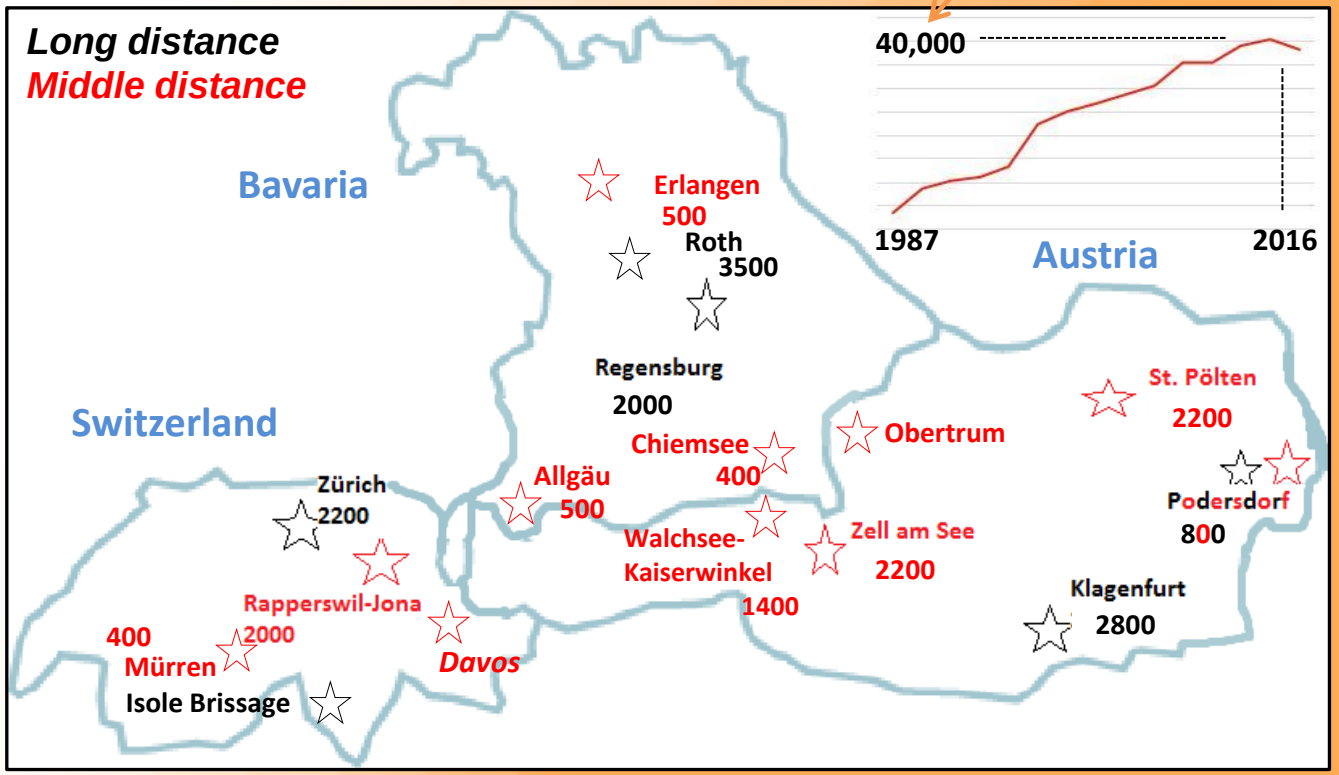
worldwide

Organizers - Labels
ITU
WTC
Challenge
Local ones

Distance	Swim	Bike	Run
Sprint	0.75	20	5
Short/Olympic	1,5	40	10
Middle/Half*	1.9	90	21
Long (Ironman)*	3.8	180	42

- exact km for long: 3,86 / 180.25 / 42.20
  middle: 1.9 / 90 / 21.1

Country	Events	Competitions	Clubs	Participants
Germany	>600	>1,500	1,542	~270,000
Bavaria	~100		351	~60,000
Austria	103	-	288	~40,000
Switzerland	46	322	76	~31,000
ÖTRV (2016), S. 33		Swiss Triathlon (2015), S. 23		DTU (2016), S. 6,9



Outline:

Increasing number of triathlon related injuries

Lifestyle

Why?
What can be done?

Boom

Increasing popularity of triathlon

Previous findings:

- ***Running – highest incidence of injuries***
- ***Balanced vs. accumulated impacts onto the body***
- ***Impact of crossover effects***
- ***Differences of injuries and concerning their incidences according to those of individual sports***
- ***Triathlon – summation of 3 disciplines vs. sport in its own right***

Previous findings:

- ***Injuries in long distance***

incidence for competitions

6x (Egermann et al., 2003)

13 x (Zwingenberger et al., 2014)

higher than for training

incidence per 1000 h exposure

0.71 (Egermann et al., 2003)

0.88 (Zwingenberger et al., 2014)

incidence per discipline

%	%	%	
16.0	32.0	60.0	Vleck (2010)
5.8	54.8	33.7	Egermann et al. (2003)
5.0	20.0	58.0	Massimo et al. (1988)

incidence overall

Total	Traumatic	Overuse		
	23.6	87.0	Andersen et al. (2013)	
	48.0 50.0	68.0 57.0	M W	Vleck (2010)
74.8		76.2	Egermann et al. (2003)	
		91.0	O'Toole et al. (1998)	
	22.0	78.0	Massimo et al. (1988)	

Aim of the survey:

- ***Evaluation of the most frequent and common injuries in long distance triathlon***

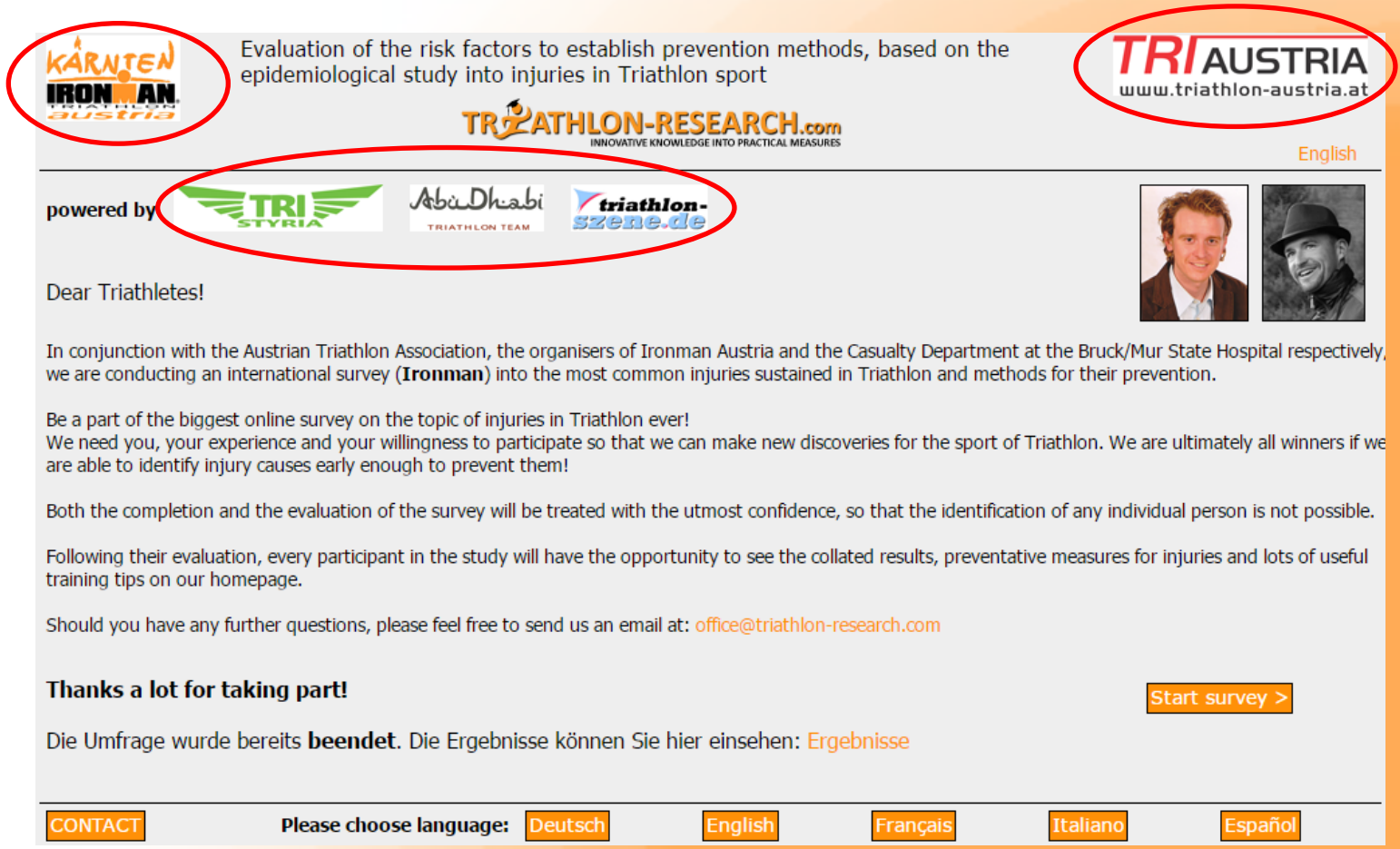
with special regards to:

- ***Identifying the links between training based risk factors and the most common symptoms***
- ***The three disciplines***
- ***A comparison with the discipline specific athletes***
- ***Distances of triathlon***
- ***Performance levels***
- ***Sex***

TRIATHLON-RESEARCH.com
INNOVATIVE KNOWLEDGE INTO PRACTICAL MEASURES

Study design:

- ***Cross-sectional study***
  - ***Online questionnaire***
  - ***5 different languages***
  - ***87 main questions***
  - ***20 – 30 min. duration***
  - ***Cooperation with:***



TRIATHLON-RESEARCH.com
INNOVATIVE KNOWLEDGE INTO PRACTICAL MEASURES

Measurement:

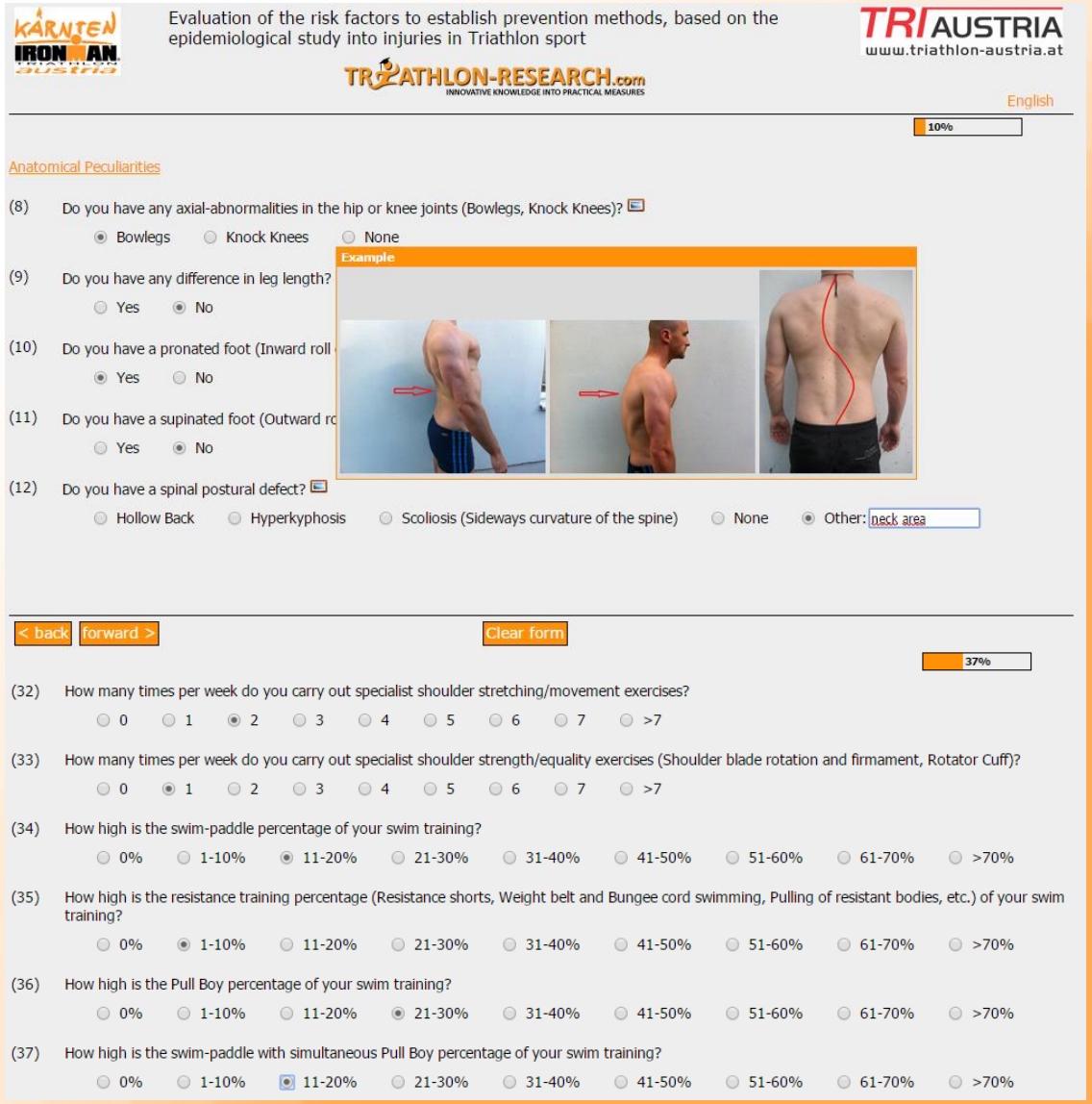
- ***Subject areas***

  1-14: Intrinsic factors
  general information, antropometrie …

  15-57: Extrinsic factors
  training habits & training material …

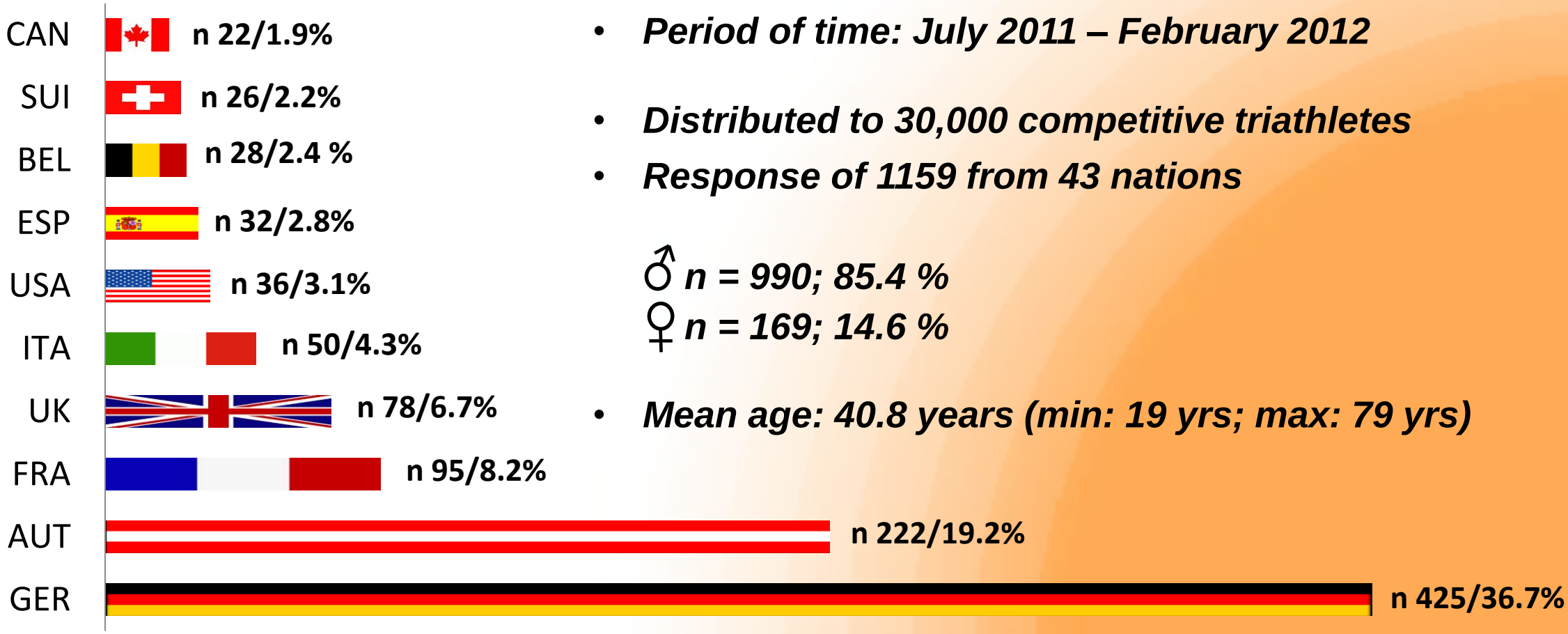
  58-63: Dietary supplements
  motivation, dose …

  64-87: Injuries
  kind, nature, treatment …



TRIATHLON-RESEARCH.com
INNOVATIVE KNOWLEDGE INTO PRACTICAL MEASURES

Sample:



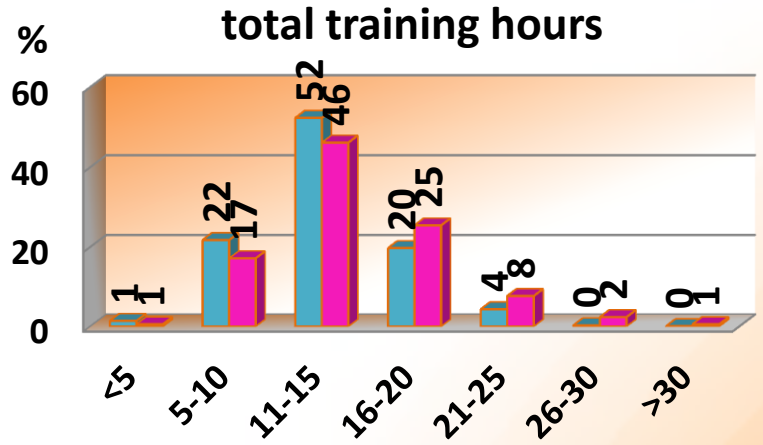
- *Period of time: July 2011 – February 2012*
- *Distributed to 30,000 competitive triathletes*
- *Response of 1159 from 43 nations*

♂ *n = 990; 85.4 %*
♀ *n = 169; 14.6 %*

- *Mean age: 40.8 years (min: 19 yrs; max: 79 yrs)*

TRIATHLON-RESEARCH.com
INNOVATIVE KNOWLEDGE INTO PRACTICAL MEASURES

Results (1):



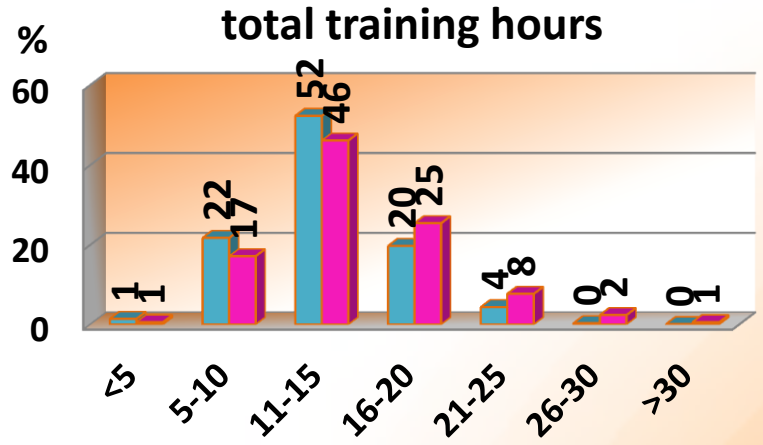
~50% of
men & women
train 11-15 h / week

General information (mean)		
	M	W
Age (year)	41,07	39,46
Height (cm)	179,85	167,28
Weight (kg)	75,26	59,69
Participation (total)	3,63	3,50
Participation/year	1,18	1,21
Active time (year)	6,41	6,83
Total time (hh:mm)	11:24	12:10
Swimsplit (hh:mm)	01:12	1:14
Bikesplit (hh:mm)	05:44	6:10
Runsplit (hh:mm)	4,10h	4:26

	Sessions / week	Int. Se. / week	Km / week
	M: 2.25 (mean) W: 2.52 (mean)	M: 0.96 (mean) W: 1.03 (mean)	M: 8 % ≥ 10 km W: 14 % ≥ 10 km
	M: 2.72 (mean) W: 2.82 (mean)	M: 1.11 (mean) W: 1.13 (mean)	M: 62 % > 150 km W: 61 % > 150 km
	M: 2.96 (mean) W: 3.19 (mean)	M: 1.17 (mean) W: 1.23 (mean)	M: 20 % > 50 km W: 16 % > 50 km

TRIATHLON-RESEARCH.com
INNOVATIVE KNOWLEDGE INTO PRACTICAL MEASURES

Results (1):



~50% of
men & women
train 11-15 h / week

General information (mean)		
	M	W
Age (year)	41,07	39,46
Height (cm)	179,85	167,28
Weight (kg)	75,26	59,69
Participation (total)	3,63	3,50
Participation/year	1,18	1,21
Active time (year)	6,41	6,83
Total time (hh:mm)	11:24	12:10
Swimsplit (hh:mm)	01:12	1:14
Bikesplit (hh:mm)	05:44	6:10
Runsplit (hh:mm)	4,10h	4:26

	Sessions / week	Int. Se. / week	Km / week
	M: 2.25 (mean) W: 2.52 (mean)	M: 0.96 (mean) W: 1.03 (mean)	~45 % of M & W < 6km & 6-10 km
	M: 2.72 (mean) W: 2.82 (mean)	M: 1.11 (mean) W: 1.13 (mean)	~55 % of M & W 150 - 300 km
	M: 2.96 (mean) W: 3.19 (mean)	M: 1.17 (mean) W: 1.23 (mean)	~50 % of M & W 31 - 50 km

Results (1):

General information (mean)		
	M	W
Age (year)	41,07	39,46
Height (cm)	179,85	167,28
Weight (kg)	75,26	59,69
Participation (total)	3,63	3,50
Participation/year	1,18	1,21
Active time (year)	6,41	6,83
Total time (hh:mm)	11:24	12:10
Swimsplit (hh:mm)	01:12	1:14
Bikesplit (hh:mm)	05:44	6:10
Runsplit (hh:mm)	4,10h	4:26

Andersen et al. (2013)	↓
Egermann et al. (2003)	≈
Zwingenberger et al. (2014)	≈
Vleck (2010)	↑

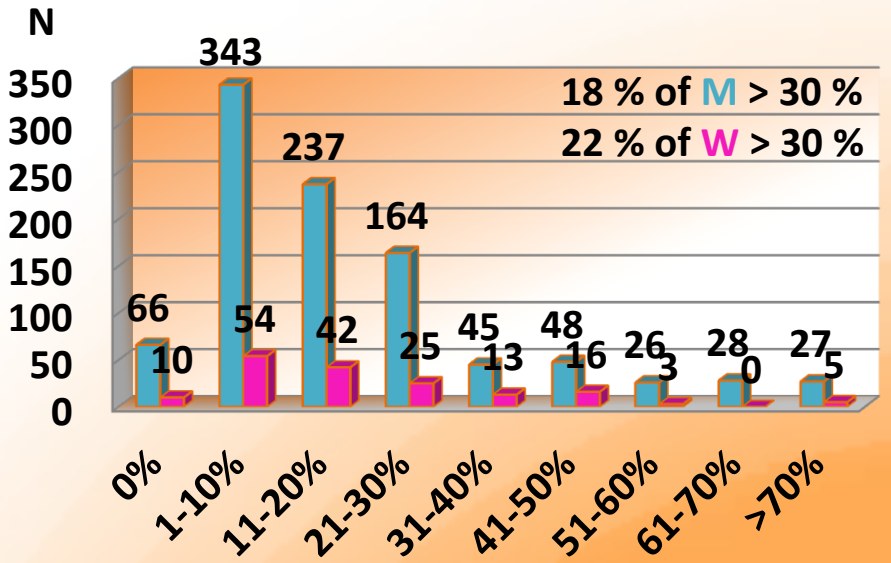
training hours / week
- **total**
- **per discipline**

TRIATHLON-RESEARCH.com
INNOVATIVE KNOWLEDGE INTO PRACTICAL MEASURES

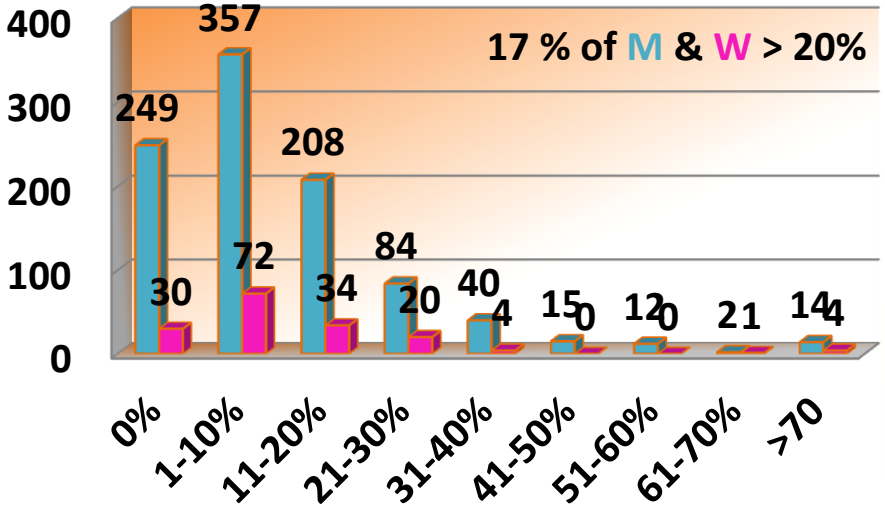
Results (1):

share of training

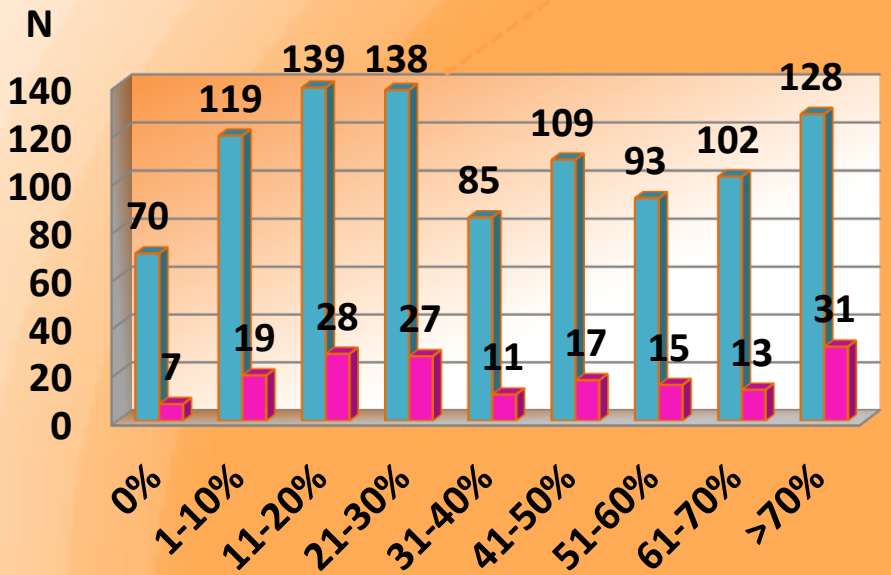
hill training



pull buoy



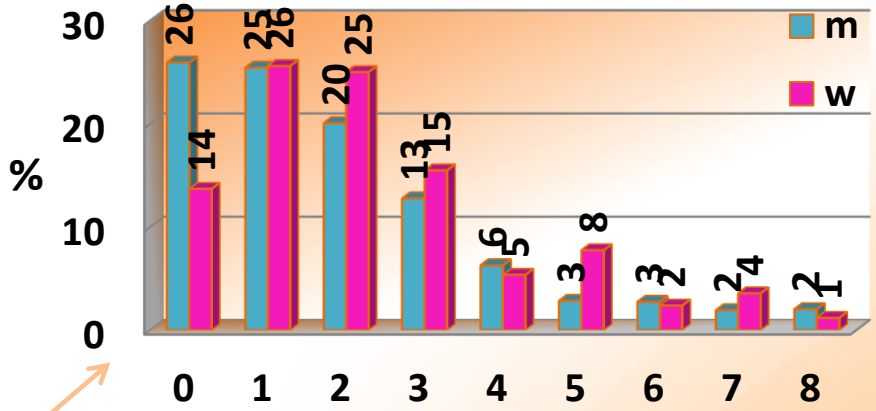
aerobar

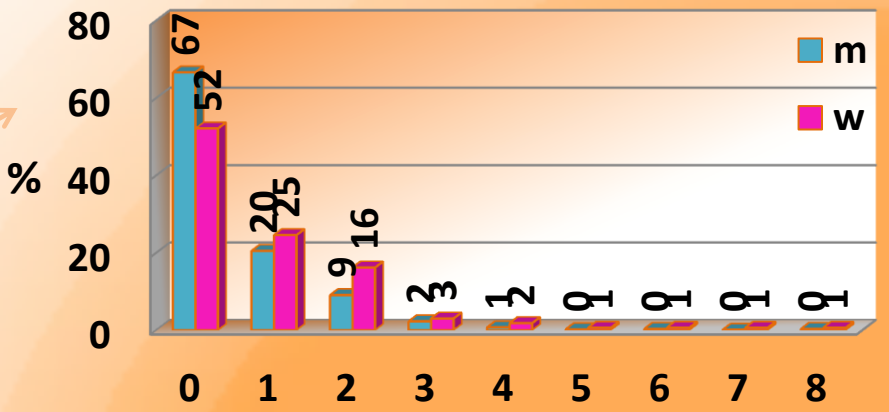


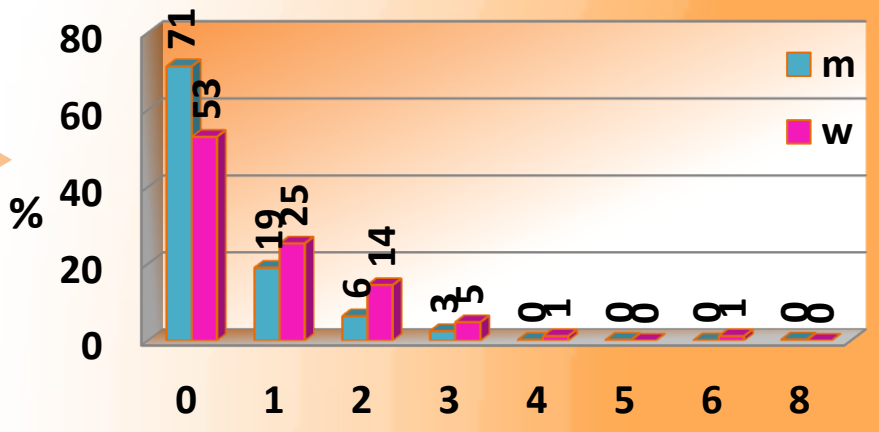
TRIATHLON-RESEARCH.com
INNOVATIVE KNOWLEDGE INTO PRACTICAL MEASURES

Results (1):

Sessions/week (mean)		
	M	W
Stretching-general	1,89	2,31
Stability-general	0,61	1,14
Strenght-upper body	0,98	1,21
Strenght-core	1,22	1,89
Strenght-lower body	0,82	1,14
stretching/movement shoulder	0,77	0,83
Stability-shoulder	0,54	0,89
stretching/movement run	1,33	1,55
Stability-run	0,44	0,81

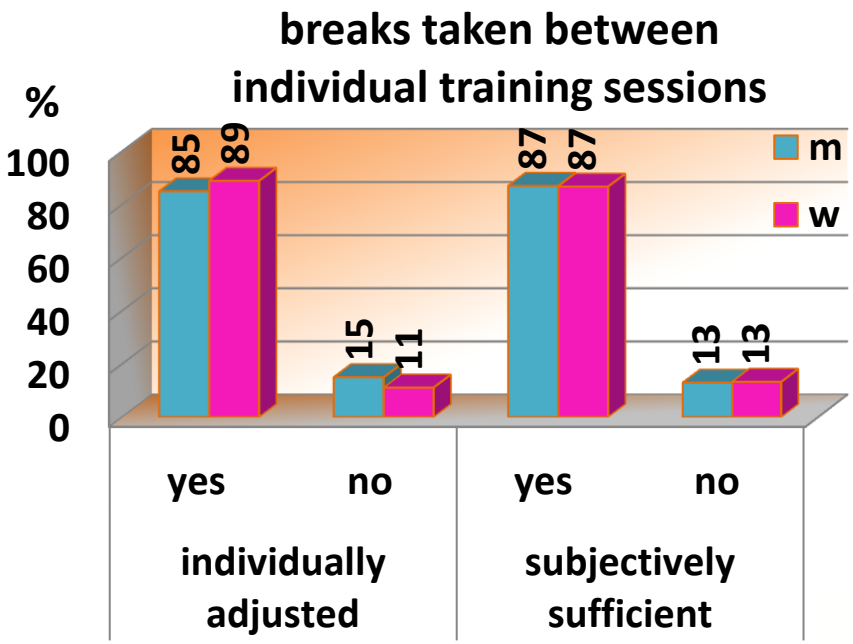


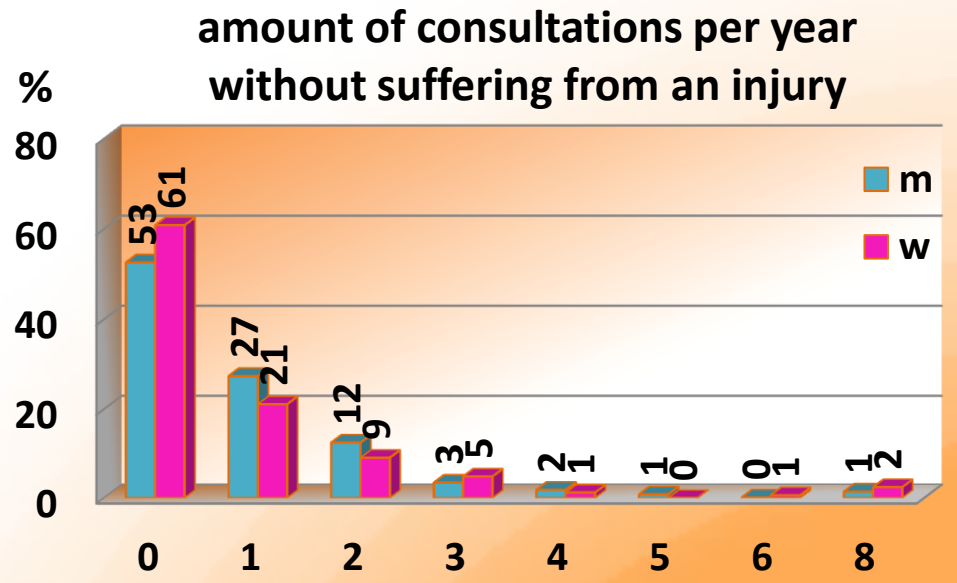


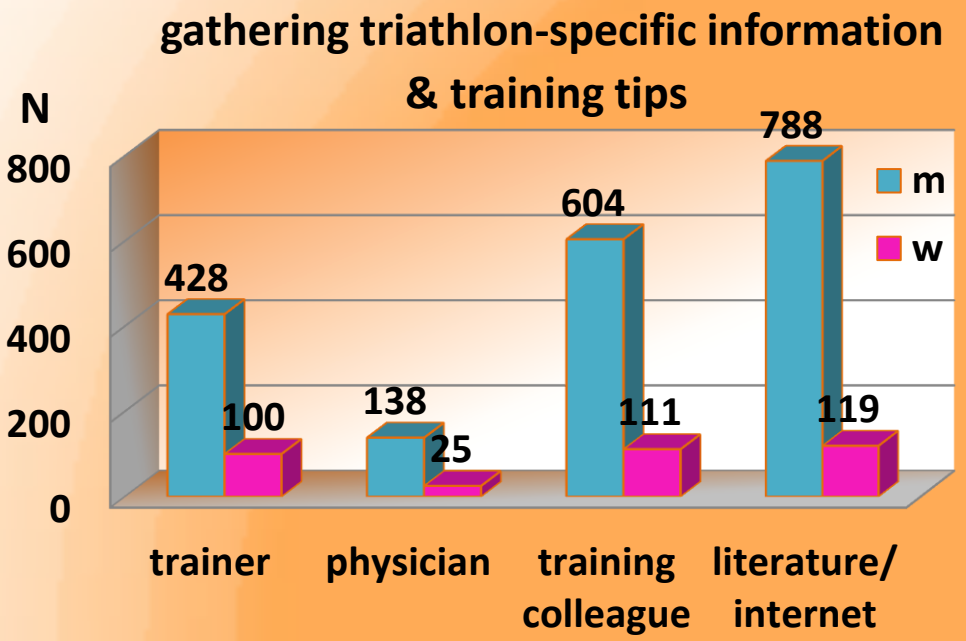


TRIATHLON-RESEARCH.com
INNOVATIVE KNOWLEDGE INTO PRACTICAL MEASURES

Results (1):

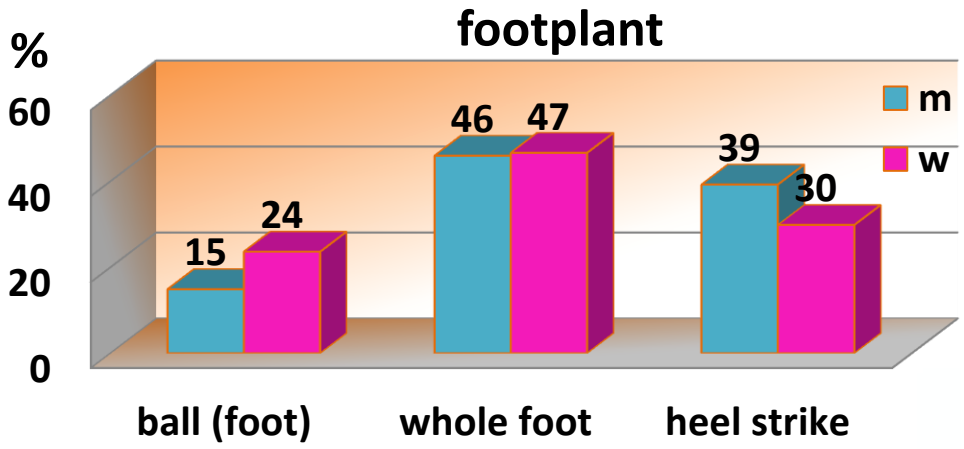


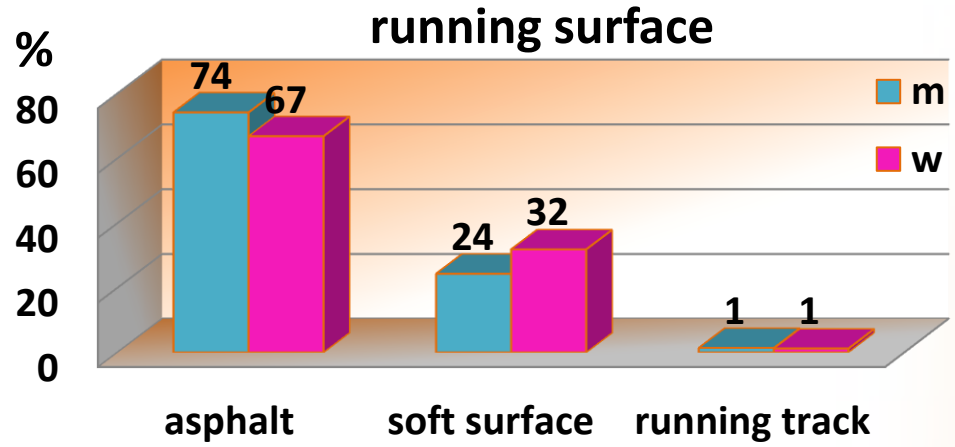




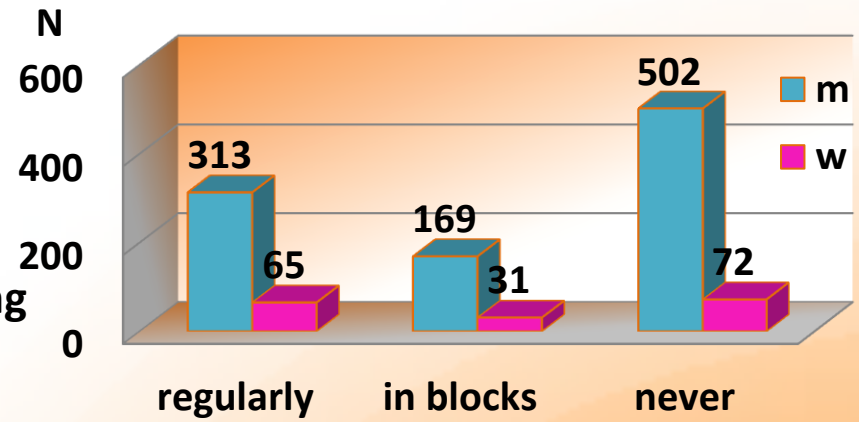
TRIATHLON-RESEARCH.com
INNOVATIVE KNOWLEDGE INTO PRACTICAL MEASURES

Results (1):

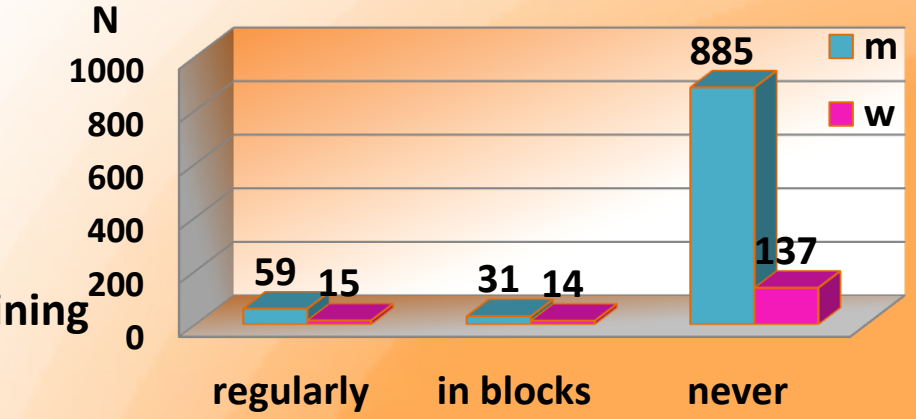




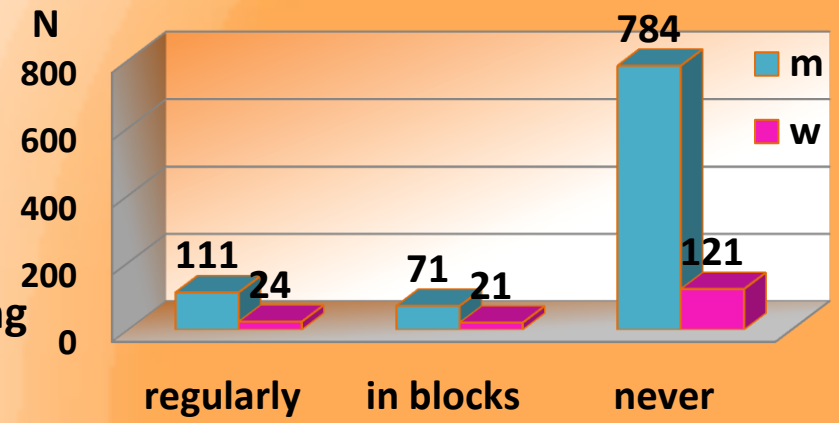
technical training



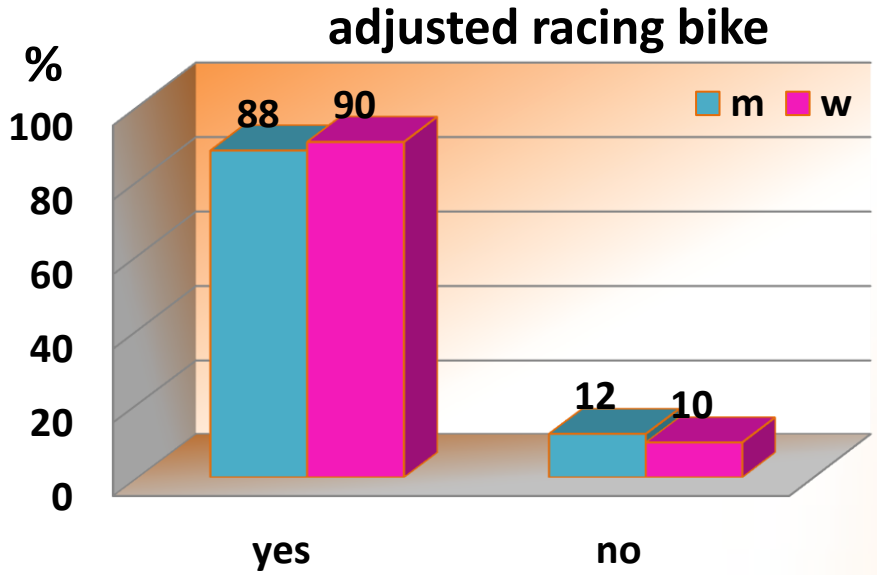
technical training

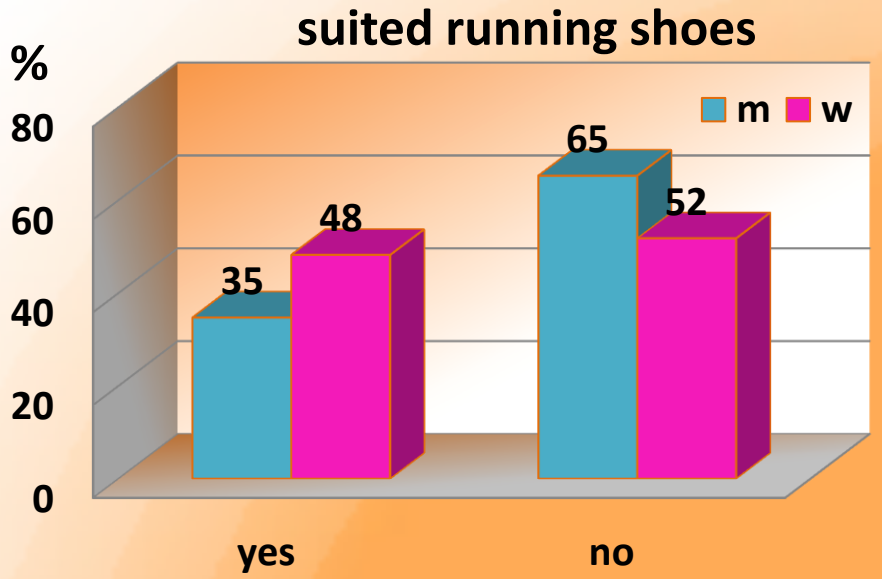


technical training

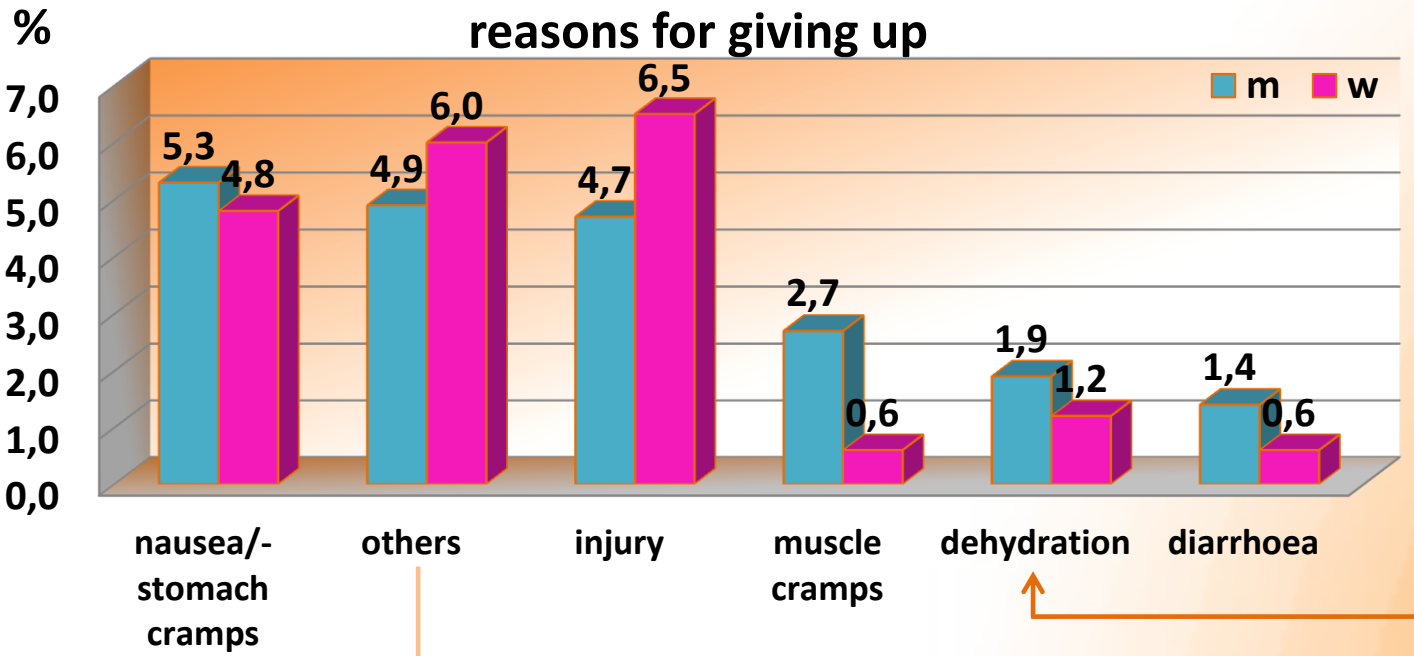


Results (1):


adjusted racing bike
%
100
80
60
40
20
0
m
w
88
90
12
10
yes
no


suited running shoes
%
80
60
40
20
0
m
w
35
48
65
52
yes
no

Results (1):



Dehydration/Exhaustion:
Hiller et al. (1987)
Laird (1989)
Rimmer und Coniglione (2012)
50 % - 72 %

<u>prospective observational study:</u>
prevalence of injuries: 38%
- 51 % dehydration
- 36 % muscle cramp

cf.

Baillot & Hue (2015)
Laursen et al. (2006)

lack of training, mental/motivation problems, weather conditions, asthma, technical probelms, inhaled alga, wife was giving birth to his first son!...

TRIATHLON-RESEARCH.com
INNOVATIVE KNOWLEDGE INTO PRACTICAL MEASURES

Variables:

➢ Dependent variables

Swim	Bike	Run
Shoulder pain	Lumbar pain	Achillodynia
	Cervical pain	Knee pain*
	Genital pain	Shin splints
	Knee pain	Fasciitis plantaris
		Lumbar pain

* classified in runner's knee (PFSS) and iliotibial band friction syndrom (ITBFS)

➢ Independent variables

	Swim	Bike	Run
Fixed independent Variables			
Sector: Age + anatomical abnormalities	Age (groups)		
	Postural deformities		
		Axial-abnormalities	
		´Leg lengths inequality	
		Pronation (foot)	
		Supination (foot)	

	Swim	Bike	Run
Independent Variables			
Section: Training	Total training volume (h)		
	Kilometers		
	Hours		
	Intensive sessions (>85% of max. performance)		
	Upper body-strength sessions		
	Core-strength sessions		
	Lower body-strength sessions		
	Discipline-specific stretching-/flexibility sessions		
	Discipline-specific stabilisation sessions		
	Share of swim paddels	Share of aerobar	Share of hilly km
	Share of resistant training		Belt training-sessions
	Share of pull-buoy		
	Share of swim paddels with pull-buoy		
Section: Technique	Discipline-specific technical training		
		Adjusted racing bike	Footplant
			Suited running shoes
			footplant
Section: Recovery	Regeneration-sessions per week		
	Break time – individually adjusted		
	Break time – subjectively sufficient		
	Training attitude		
Sec.: Level	Longdistance-participations - total		
	Performance level		
	Swim performance	Bike performance	Run performance
S.: IP	General stretching sessions per week		
	Amount of preventive consultations per year		

Results (2):

➢ Swimming

regions

factors for shoulder pain

Sex	Variable	N	OR	95% CI	P-value
m	Swimming technique-training	835			
	yes	413	1		
	no	422	0,69	0,47 – 1,00	0,048
	Resistance-training	835			
	0 % percentage of swimming	722	1		
	>0 % percentage of swimming	113	1,68	1,04 – 2,69	0,033
	Core-strength training/week	835			
	>1 session	278	1		
	1 session	326	0,91	0,60 – 1,37	0,656
	0 sessions	231	0,55	0,33 – 0,91	0,021
w	Swim-kilometers/week	154			
	<6 kilometers	63	1		
	6-10 kilometers	69	4,00	1,45 – 10,99	0,007
	>10 kilometers	22	4,84	1,34 – 17,40	0,016

OR = odds ratio; CI = confidence interval; m = men; w = women

N = 989 Men; N = 168 Women

Injuries (pain)	M (%)	W (%)	T (%)
Shoulder	18.7	21.4	19.1
Cervical spine	2.3	1.8	2.2
Ellbow(-joint)	2.0	1.8	2.0
Upper arm	1.1	2.4	1.3

structures

N = 142 Men; N = 24 Women

Affected areas (shoulder)	M (%)	W (%)	T (%)
Tendon	47.9	54.2	48.8
Muscel	38.7	50.0	40.4
Joint capsule	14.8	12.5	14.5
Tendon sheath	14.1	12.5	13.9

Results (2):

➢ ***Cycling***

↓

traumatic

- ***Fracture***
- ***Contusion, sprain & ligament injury***
- ***Muscular injury***

N = 989 Men; N = 168 Women

Affected areas	M (%)	W (%)	T (%)
Shoulder	19.8	17.9	19.5
thereof clavicle	30.6	26.7	30.1
Hand	12.7	14.3	13.1
thereof wrist joint	38.1	33.3	36.8
Knee	10.3	14.9	11.0
Thigh	9.9	9.5	9.9

a- traumatic

Injuries	M (%)	W (%)	T (%)
Lumbar spine (N_m=979; N_w=165)	36.6	35.2	36.4
Cervical spine (N_m=975; N_w=167)	28.2	35.9	29.3
Genital area* (N_m=988; N_w=168)	16.3	31.5	18.5
Knee (N_m=988; N_w=168)	6.8	7.7	6.9

* excl. 25 male probands with erectile dysfunction/impotence

↓ **factors**

Lumbar -> ♂ postural deformities↑

Cervical -> ♂ adapted cycle↑

♀ cycling technique training ↑

Knee -> ♂ stretching ↑

Genital -> ♂ postural deformities↑ ; regeneration↓

♀ intensive cycle-sessions↑; cycling technique training ↑

TRIATHLON-RESEARCH.com
INNOVATIVE KNOWLEDGE INTO PRACTICAL MEASURES

Results (2):

factors

➢ *Running*

a- traumatic

Injuries	M (%)	W (%)	T (%)
Achillodynia (N=968 M; 161 W)	35.8	24.8	34.3
Runner´s Knee (N=978 M; 164 W)	28.1	31.1	28.5
ITBFS (N=969 M; 165 W)	27.7	32.1	28.3
Shin splints (N=967 M; 161 W)	16.3	21.1	17.0
Fasciitis plantaris (N=967 M; 164 W)	13.0	19.5	14.0
Lumbar spine (N=976 M; 164 W)	11.6	17.0	12.4
Stress fracture MT (N=988 M; 168 W)	3.1	5.4	3.5

Factors	AT		RK		ITBFS		SS		FP		LS	
	M	W	M	W	M	W	M	W	M	W	M	W
Age	↑	↓	↓		↓		↓	↓				
Stretching			↑	↓	↓	↓						↓
Runner's level				↓		↓			↑			
Belt- training	↓						↓		↓			
Running shoes		↓			↓				↓			
Regeneration	↑		↓	↑								
Kilometers		↑					↑					
Posture						↓						↑
Supination								↑				
Leg lengths ≠	↑											
Axial-abnorm.							↑					
Underground										↑		
Foot strike			↓									
Axial-training								↑				
UB-Strength		↑										
Core-Strength				↓								
Running (h)					↓							
Totoal (h)										↑		
Physician	↓											

Strenghts:

- ***Large sample***

  1159 participants

- ***Extensive questionnaire***

  4 subjects areas

  87 main questions

Weaknesses:

- *Cross-sectional study*
  Retrospective

  Quality of the data

    Memory of the injuries
    Information about injuries
    Relation: reason vs. effect

Discussion:

➢ *Lack of comparability*

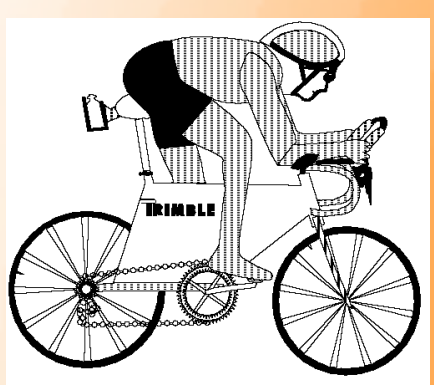
- ***Declaration of injuries*** → Athletes …
  … required knowledge about their problems?
  … knew exactly which structures of their body were affected?

- ***Definition of injuries*** → … no standardized definition
  … classification into

traumatic (crash, collision) or atraumatic (overuse)	acute or chronic	first time or reoccurring

Discussion:

- ***Lack of comparability***
  - ***Classification*** → Performance level →
    time intervals:
    … <10 h high-, 10-13 h middle- und >13 h low-performance
    vs.
    time related terminology:
    … elite-, sub-elite-, developmental-, club-level-athletes
  - ***Classification*** → Distances →
    … different training volume/intensities and methods
    … adaptation to the material used -> aero bar



→

Discussion:

- ***Lack of comparability***
  - ***Nomenclature*** → Distances →

1,5 km swim
40 km bike
10 km run

„Olympic distance“ = „Short distance“

„Sprint distance“

0,75 km swim
20 km bike
5 km run

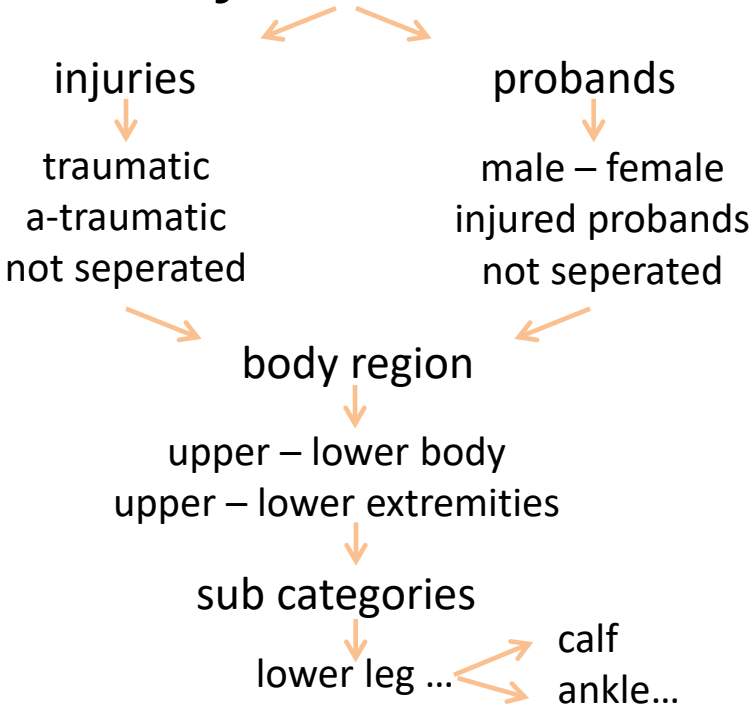
  - ***Nomenclature*** → Injuries → „acute“ „traumatic“

Discussion:

- ***Lack of comparability***
  - ***Nomenclature*** — Injuries
    - German speaking language areas → „runner‘s knee“ = „Iliotibial band friction syndrom (ITBFS)“ (lateral knee pain)
    - Anglo-American language areas → „runner‘s knee“ ≠ „Iliotibial band friction syndrom (ITBFS)“; „runner‘s knee“ → „PFPS“ (anterior knee pain)
  - ***Nomenclature*** → Injuries → Hip, Groin, Pelvis, Shoulder → ? → Upper body, Trunk, Lower body

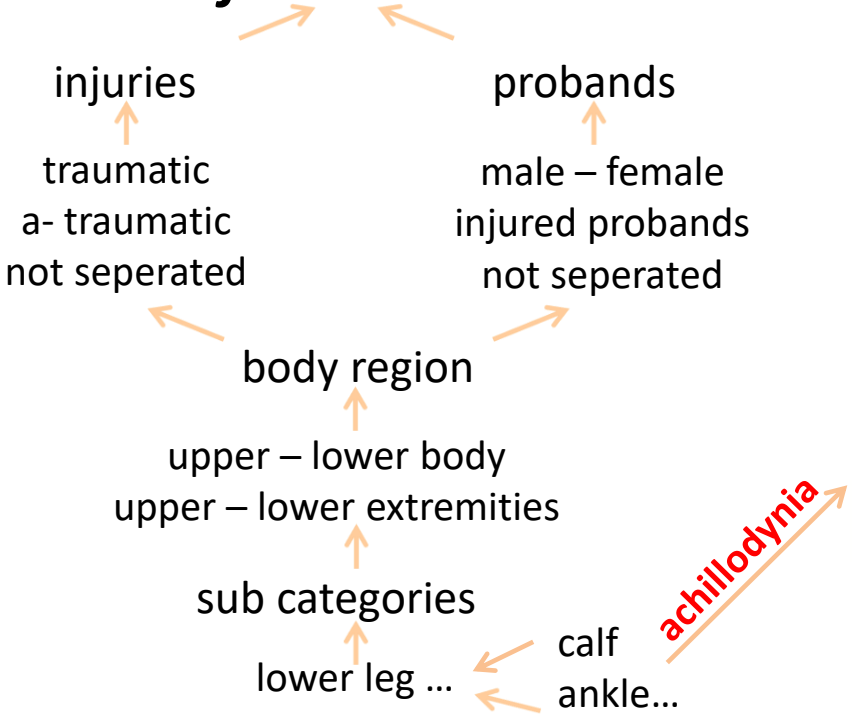
Discussion:

- ***Lack of comparability***
  - ***References***



Discussion:

- ***Lack of comparability***
  - ***References***



15 % of the athletes have achillodynia
15 % of the injured athletes have achillodynia
15 % of the athletes with overused injuries have achillodynia

15 % of injuries are concerning achillodynia
15 % of all overused injuries are concerning achillodynia
15 % of all running injuries are concerning achillodynia
15 % of all overused running injuries are concerning achillodynia
15 % of all muscel- and tendon injuries are concerning achillodynia
15 % of all tendon injuries are concerning achillodynia

15 % of all injuries of the lower body are concerning achillodynia
15 % of all a-traumatic injuries of the lower body are concerning achillodynia
15 % of all running injuries of the lower body are concerning achillodynia
15 % of all atraumatic running injuries of the lower body are concerning achillodynia

15 % of all injuries of the lower limb are concerning achillodynia
15 % of all a-traumatic injuries of the lower limb are concerning achillodynia
15 % of all running injuries of the lower limb are concerning achillodynia
15 % of all atraumatic running injuries of the lower limb are concerning achillodynia

15 % of all injuries of the lower leg are concerning achillodynia
15 % of all a-traumatic injuries of the lower leg are concerning achillodynia
15 % of all running associated injuries of the lower leg are concerning achillodynia
15 % of all atraumatic running injuries of the lower leg are concerning achillodynia

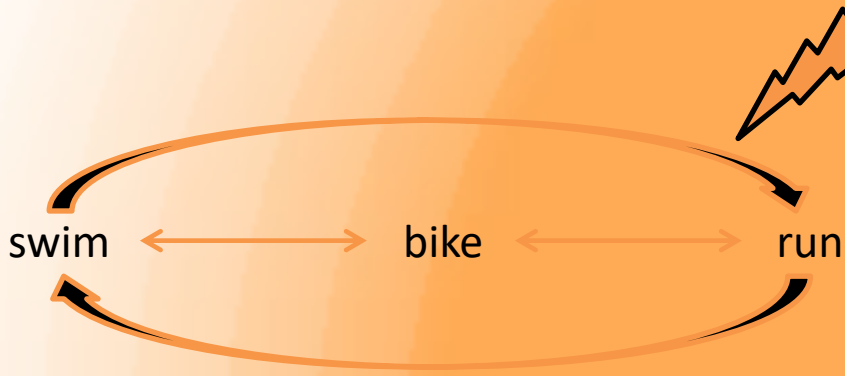
Discussion:

➢ *Lack of comparability*

- ***References*** → Frequencies of crashes →
  - Cyclists
  - Year per cyclists
  - 1,000 km
  - 1,000 hrs
  - Days per year
  - 60 % of the triathletes had at least one crash during cycling

training ? vs ? competition

- ***Crossover effects*** → Flash point of discomforts? →



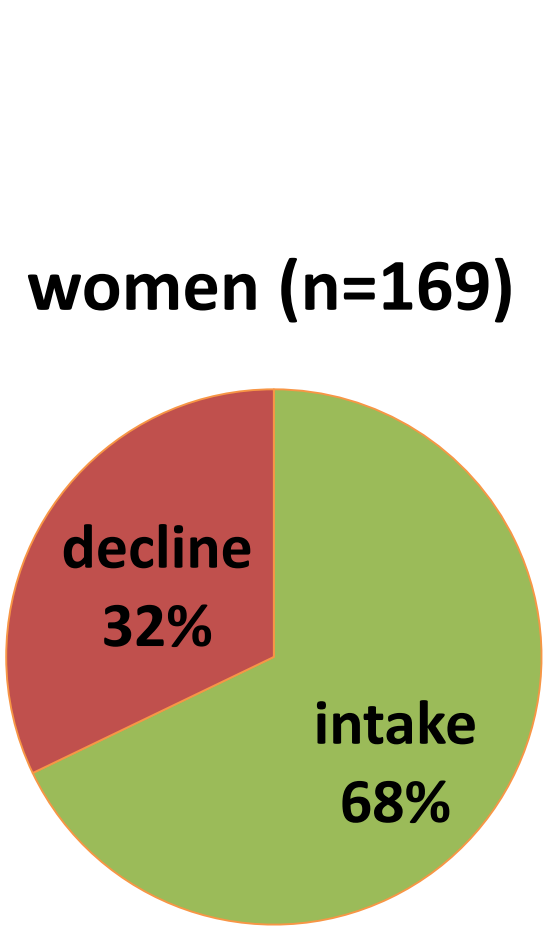
Conclusion:

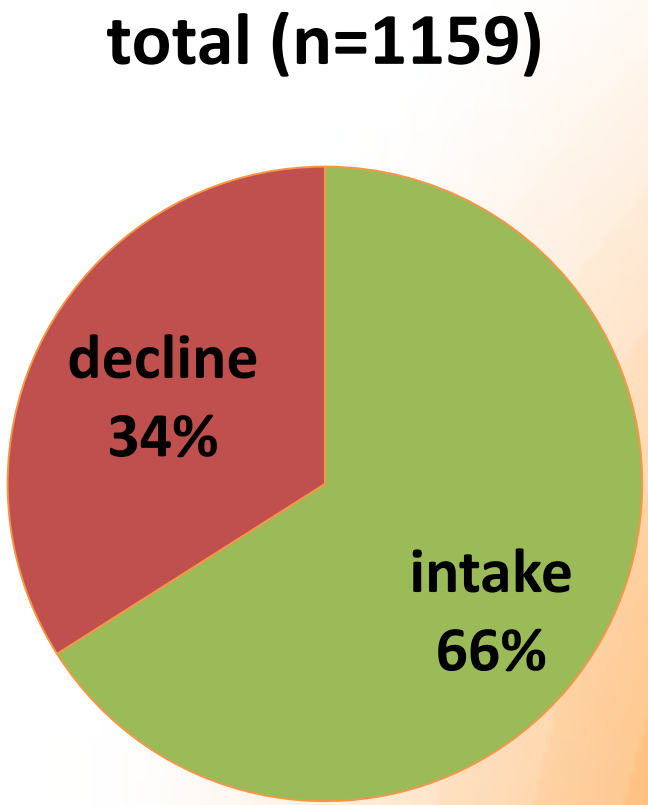
- *Triathlon (IR) is not a summation of three disciplines*
- *Incidences of injuries in triathlon (IR) and its disciplines can‘t be compared with those of individual sports*
- *Balanced vs accumulated impacts onto the body*
- *Impact of crossover effects*
- *Running has the highest incidence of injuries*

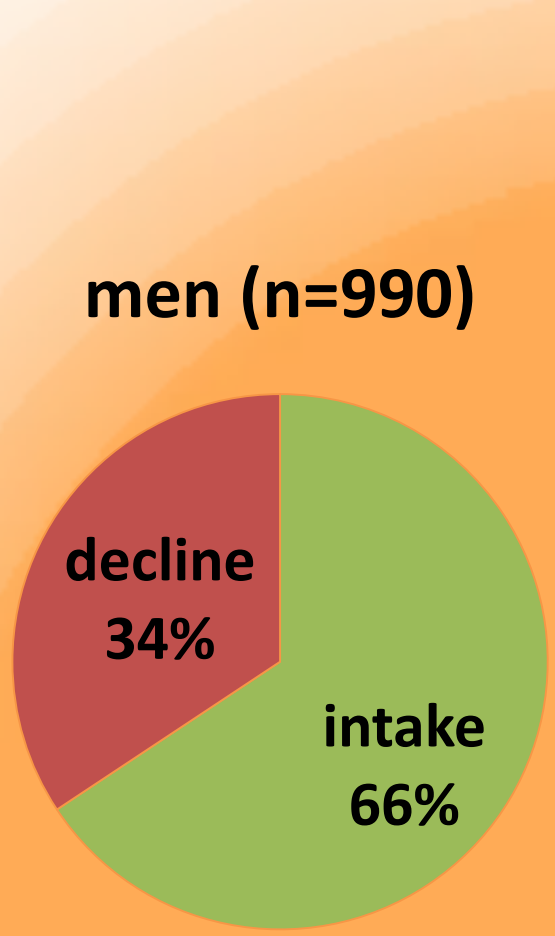
… depends on Volume / Intensity

Dietary supplement:

Dietary supplement intake:







TRIATHLON-RESEARCH.com
INNOVATIVE KNOWLEDGE INTO PRACTICAL MEASURES

Ranking of dietary supplements

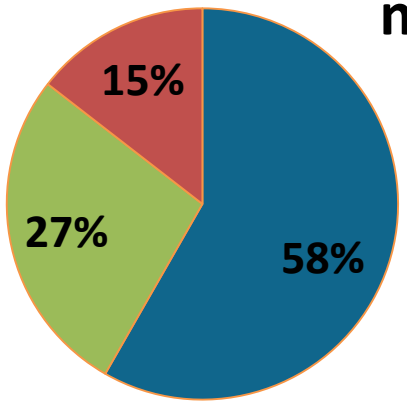
M=649; W=114; T=763

		M/n	W/n	T/n	M/%	W/%	T/%			M/n	W/n	T/n	M/%	W/%	T/%
1.	Magnesium	393	72	465	61	63	61	10.	Selenium	126	21	147	19	18	19
2.	Vitamin C	292	57	349	45	50	46	11.	Base powder	107	22	129	16	19	17
3.	Electrolyte	227	40	267	35	35	35	12.	L-glutamine	106	16	122	16	14	16
4.	Calcium	207	44	251	32	39	33	13.	L-carnitine	106	16	122	16	14	16
5.	B-vitamins	198	39	237	31	34	31	14.	Others	74	15	89	11	13	12
6.	Zinc	199	36	235	31	32	31	15.	Coenzyme Q10	61	13	74	9	11	10
7.	BCAAs	199	20	219	31	18	29	16.	Creatine	77	8	85	12	7	11
8.	Essent. aminos.	183	24	207	28	21	27	17.	Taurine	63	8	71	10	7	9
9.	Vitamin E	165	32	197	25	28	26	18.	Colostrum	41	4	45	6	4	6

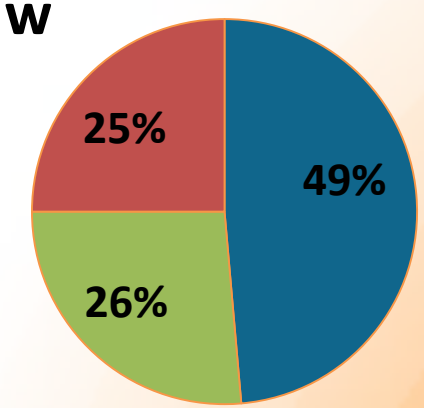
"Daily" doses of different dietary supplements

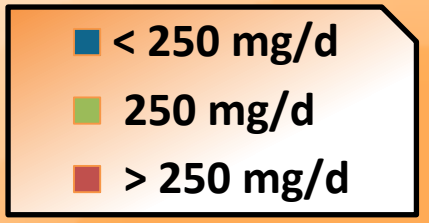
magnesium

m



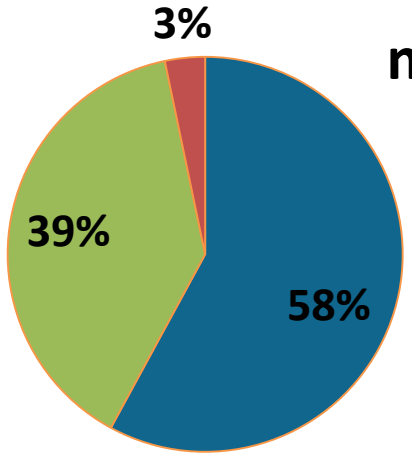
w



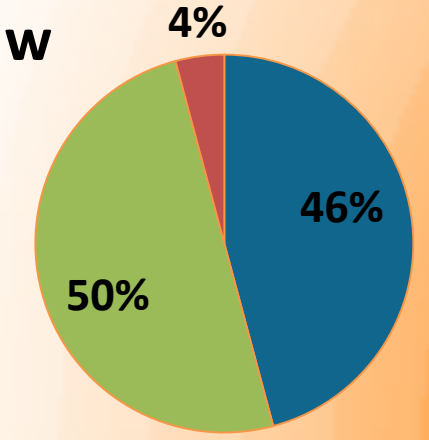


essential amino acids

m



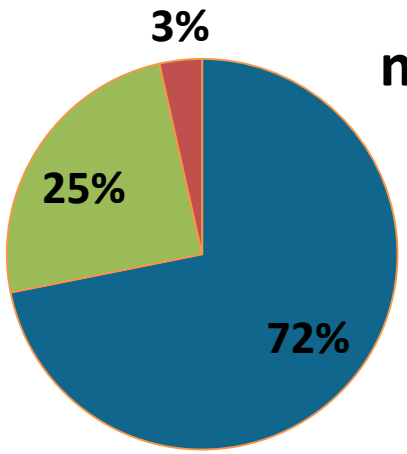
w



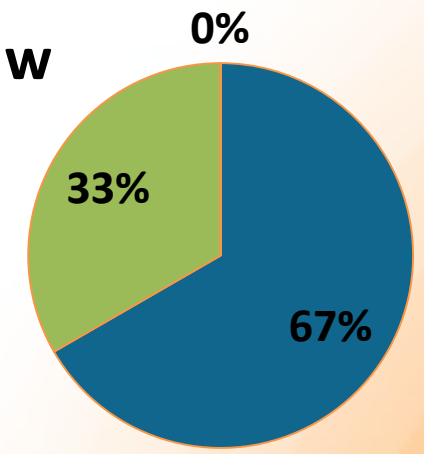
"Daily" doses of different dietary supplements

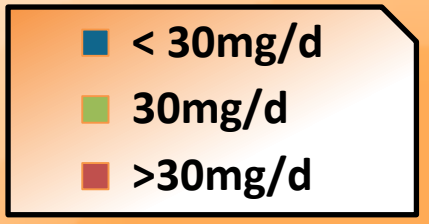
zinc

m



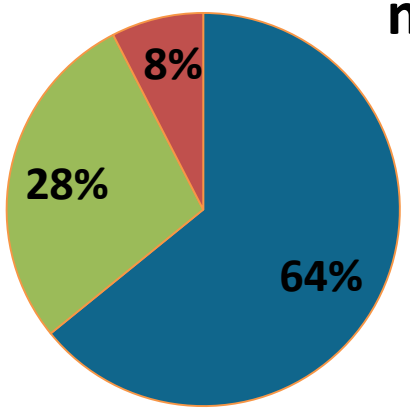
w



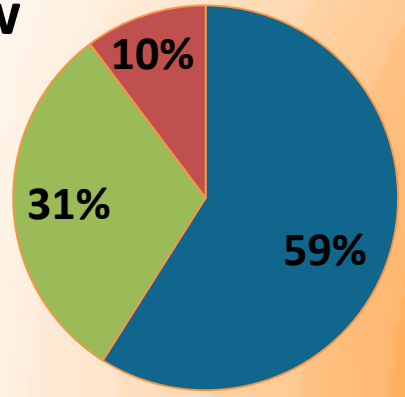


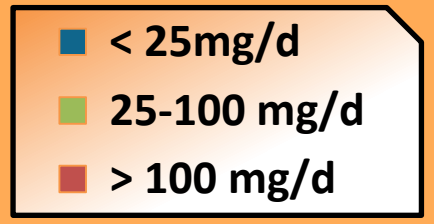
B-vitamins

m

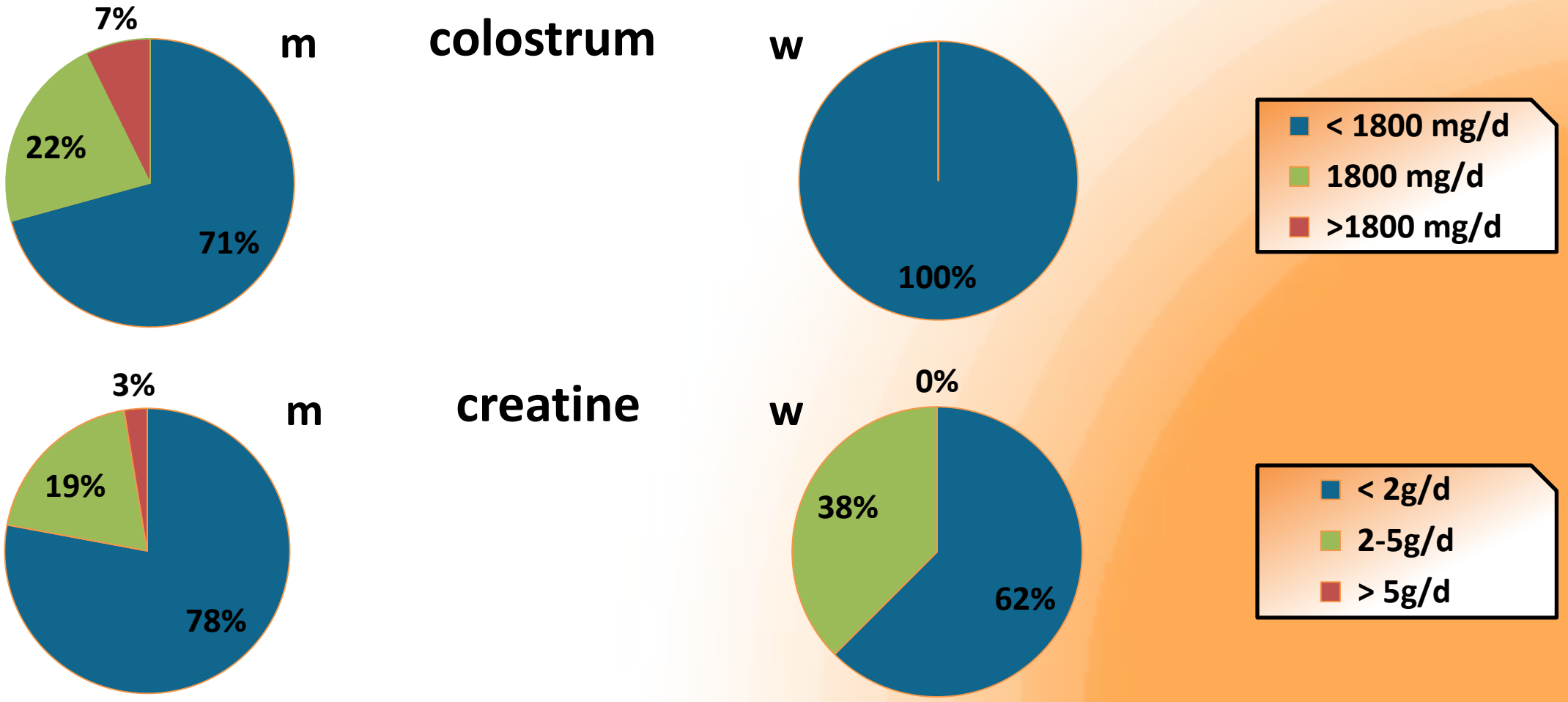


w



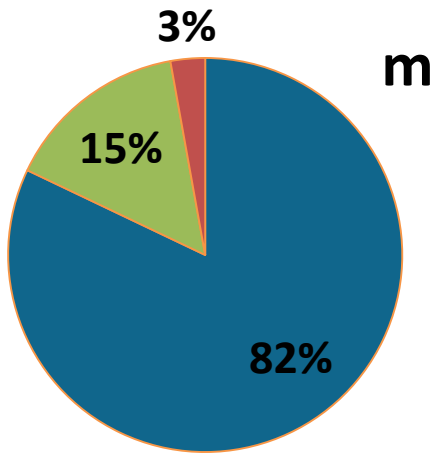


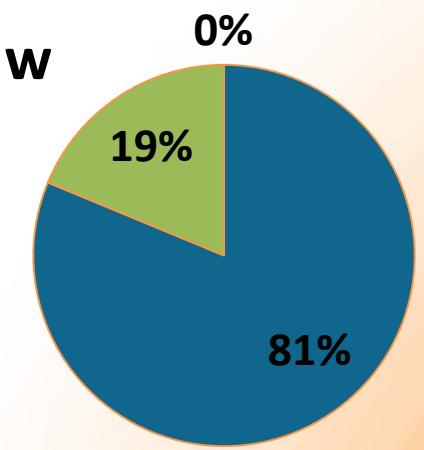
"Daily" doses of different dietary supplements

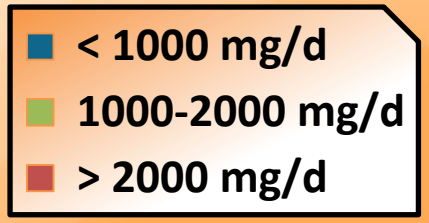


"Daily" doses of different dietary supplements

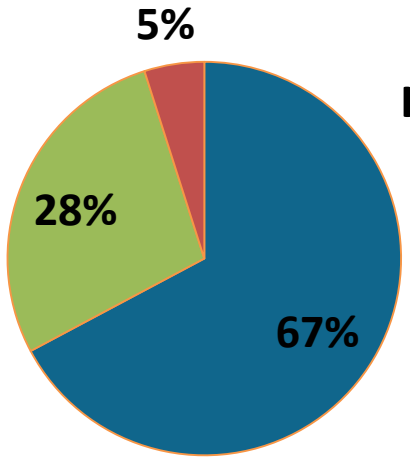
l-carnitin

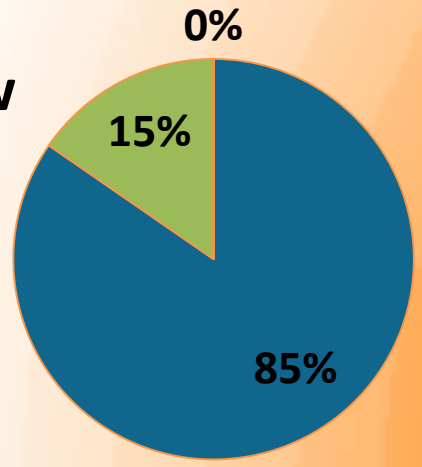


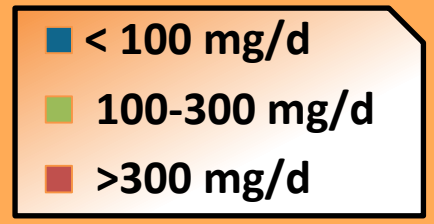


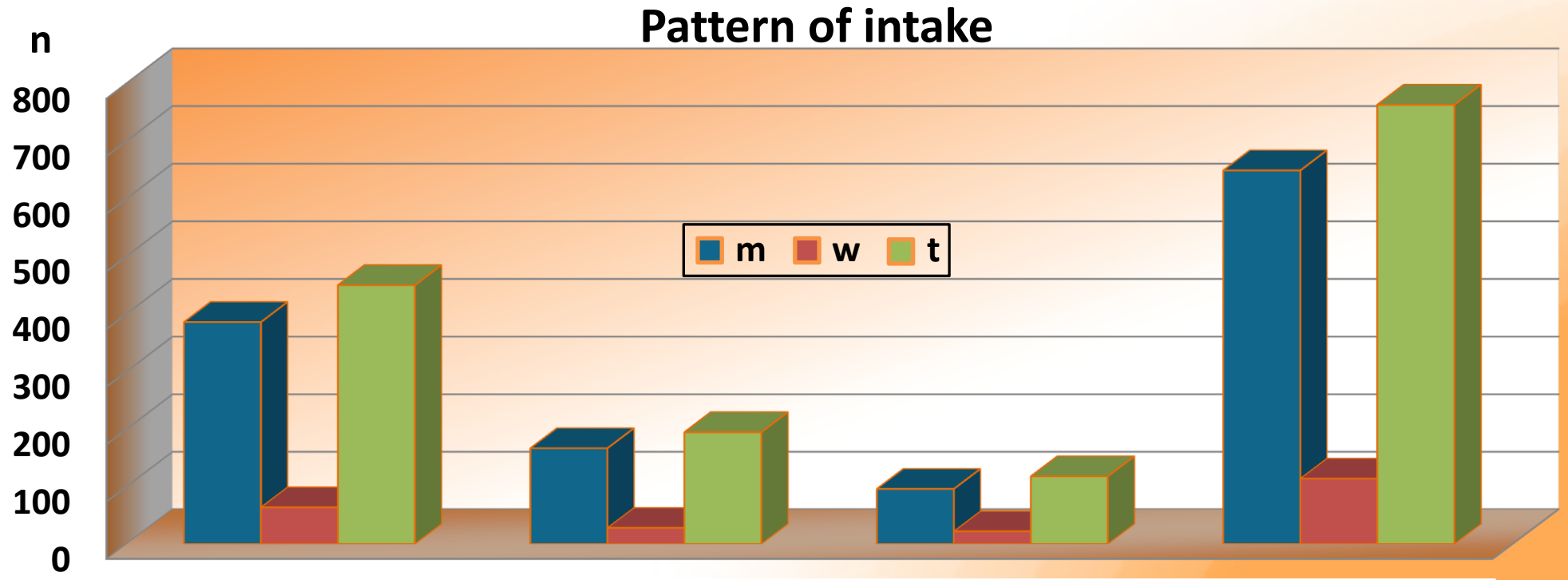


coenzym-Q10



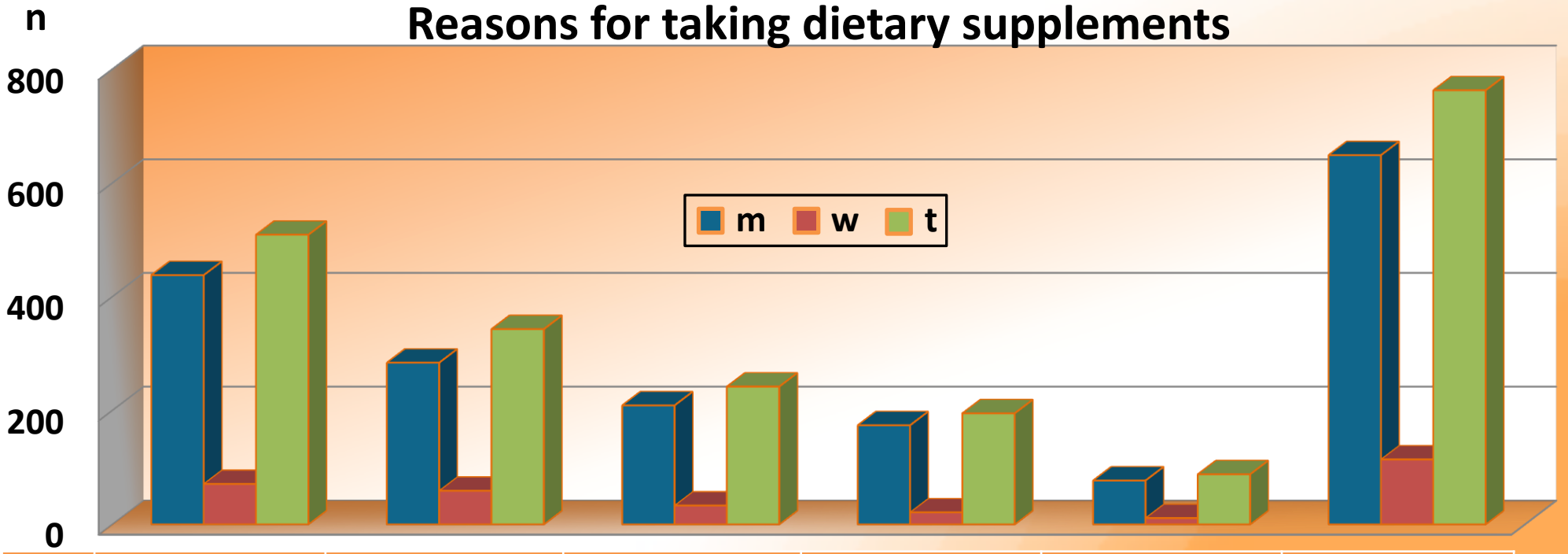






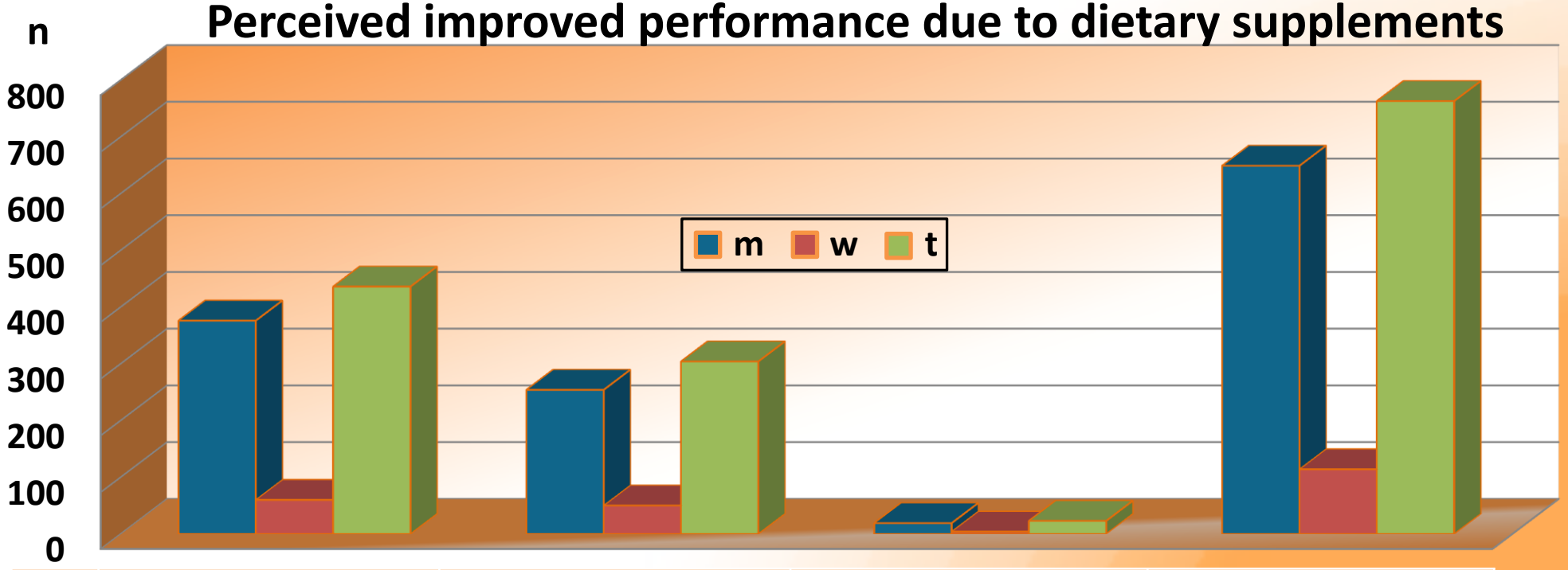
	regularly		before competition		block dietary course		total
	n	%	n	%	n	%	
m	386	39	167	17	96	10	649
w	64	38	28	17	22	13	114
t	450	39	195	17	118	10	763

Reasons for taking dietary supplements



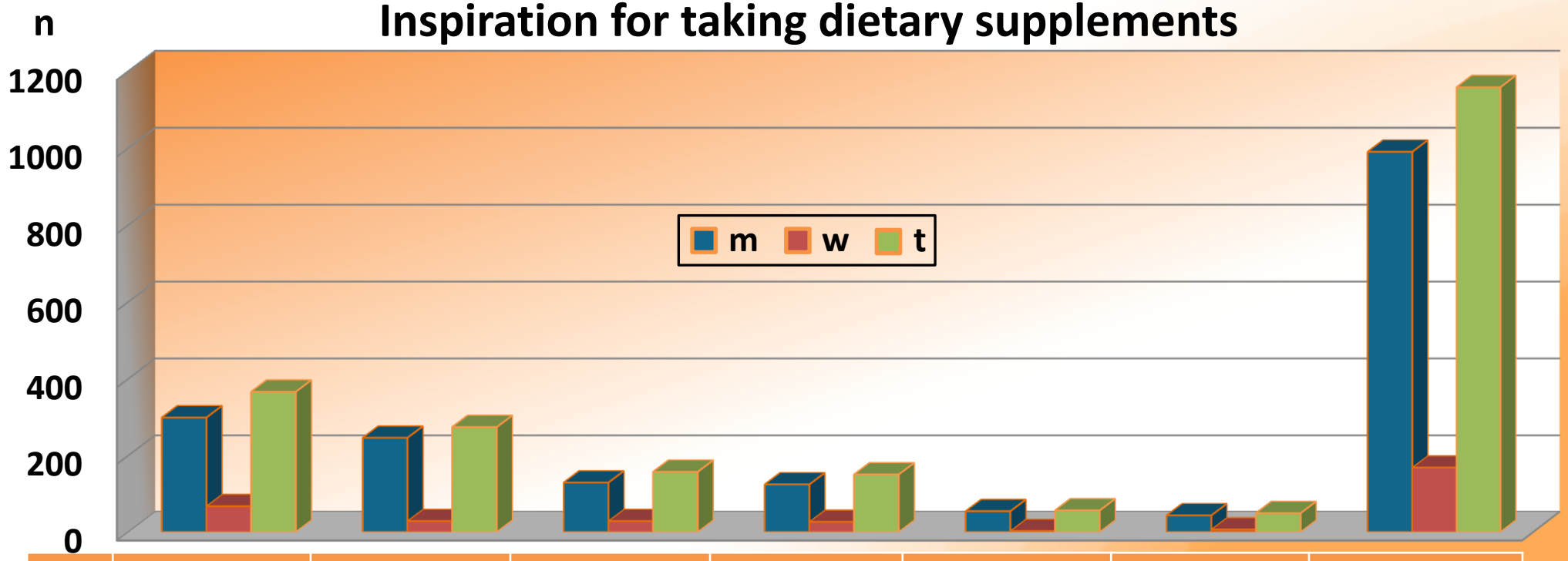
	recovery		illness resistance		injury prevention		endurance		strength		total
	n	%	n	%	n	%	n	%	n	%	
m	438	67	284	44	209	32	174	27	77	12	649
w	71	62	59	52	33	29	21	18	11	10	114
t	509	67	343	45	242	32	195	26	88	12	763

Perceived improved performance due to dietary supplements



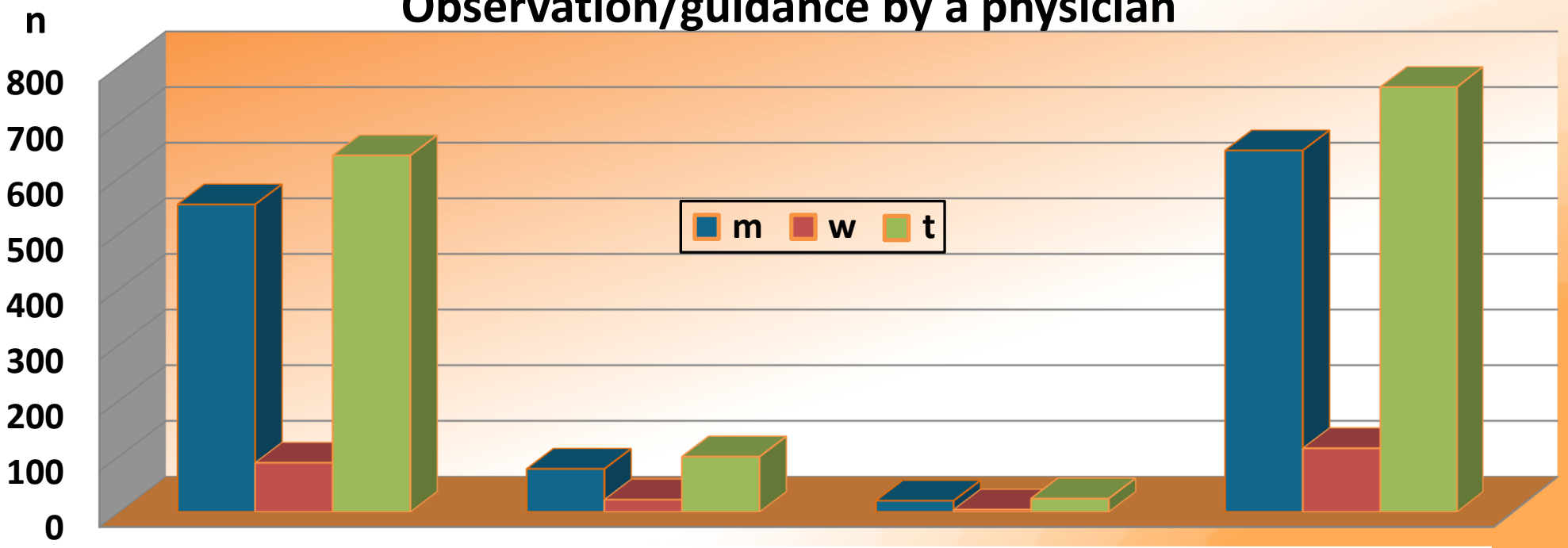
	no		yes		no response		total
	n	%	n	%	n	%	
m	376	58	254	39	19	3	649
w	60	53	50	44	4	4	114
t	436	57	304	40	23	3	763

Inspiration for taking dietary supplements



	own initiative		literature		physician		trainer		pharmacist		physio-therapist		total
	n	%	n	%	n	%	n	%	n	%	n	%	
m	299	46	246	38	129	20	124	19	54	8	43	7	649
w	67	59	28	25	28	25	26	23	2	2	6	5	114
t	366	48	274	36	157	21	150	20	56	7	49	6	763

Observation/guidance by a physician



	no		yes		no response		total
	n	%	n	%	n	%	
m	552	85	77	12	20	3	649
w	88	77	22	19	4	4	114
t	640	84	99	13	24	3	763

Conclusion:

- *Overdose*
- *Guidance by experts strongly recommended*
- *Overdose can also cause negative effects*

Thank you for your attention

References:

ÖTRV. Jahresbericht 2016. Retrieved 14/06/2016, from http://www.triathlon-austria.at/de/aktuelles-news/downloadcenter

Swiss Triathlon. Jahresbericht 2015. Retrieved 14/06/2016, from https://swisstriathlon.ch/inside/downloadcenter

DTU. Triathlon in Deutschland. Zahlen, Fakten & Hintergründe Retrieved 14/06/2016, from http://www.dtu-info.de/footer/triathlon-in-zahlen/triathlon-in-zahlen.html

Beanspruchung durch Triathlon

Herz-Kreislauf-System

- Herz
- Koronararterien
- Vorstart - zentrale Mitinnervation

Energiebereitstellung – Ernährung

- Start (Schwimmen)
- Carboloading
- Energiebedarf
- Verpflegung

Thermoregulation

- Hyperthermie
  - Dehydration
  - Hitzeerschöpfung
  - Hitzeschlag
  - Hyponatremie
- Hypothermie

Institute of Sports Science, Karl-Franzens-University Graz

Belastung durch Triathlon

Belastungskomponenten

- Wettkampf / Training

Schwimmen

- Neoprenanzug
  - Positive Auswirkungen
  - Negative Auswirkungen
- Wasserschatten
- Charakteristik Schwimmbelastung

Radfahren

- Gewicht-/Kraftübertragung
- Bike fitting
- Belastete Körperregionen

Übergang Radfahren-Laufen

- Unterschied/Anforderungen
- "Niveau" der AthletInnen
- Laufökonomie
- (Bodenreaktions-)Kräfte
- Cross-over-Effekte