

ANALYSES OF LOAD AND EFFORT OF HANDBALL PLAYERS

(aplication for the training)

- ▶ In the last ten or fifteen year's handball became a very fast sport game. The most evident practical changes are:
 - more attacks per match; in average teams scored more goals per match,
 - many attacks finished in a few seconds – there are no more very long and slow attacks with many interruptions,
 - as a consequence of this fact – many turnovers,
 - almost all attacks begin with fast break,
 - in the last years players try to execute as much as possible the fast throw of,

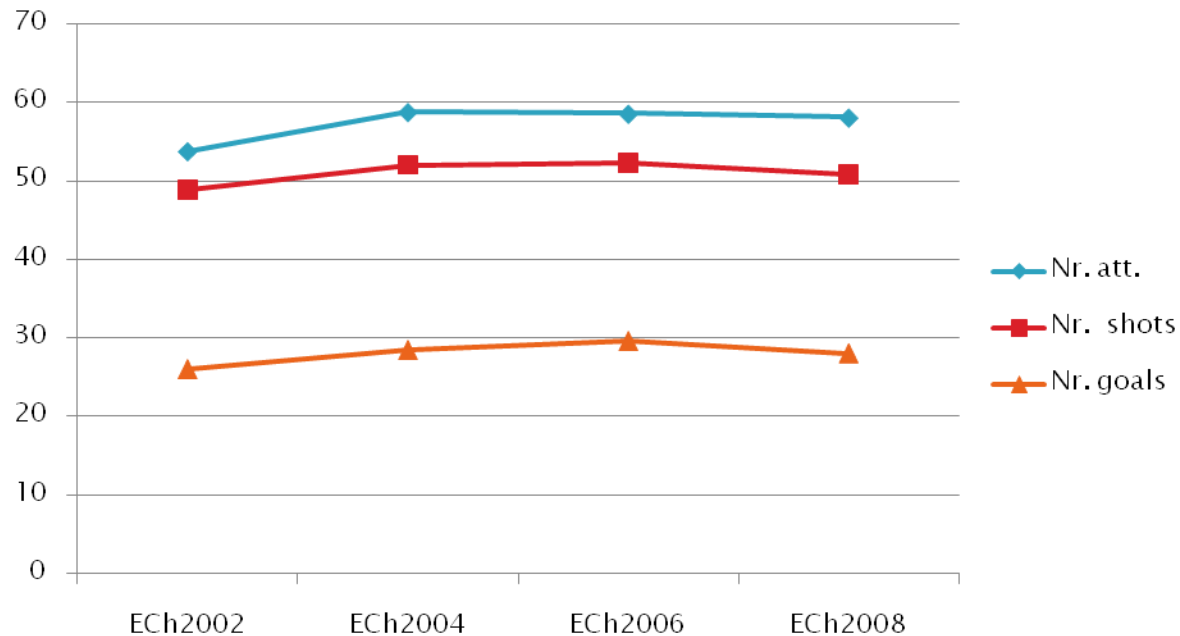
- players run more and faster;
- more and more new technical and tactical elements which are improved up to perfection,
- less vast time when nothing is happened on the playground,
- exist a tendency to create such typ of player who will be able to execute a wide range of tasks and to play on different playing positions;
- beside this remains also the players who are specialized for the certain tasks and are exelent by executing them (f.e. shooters for the distance, CH players in deffence, ...) althoug they are weaker as allrounder;
- Similar is valid also for the psihological firmness and the ability to be incorporeted in a team;

- ▶ The main reasons why it happened are following:
 - changes of the rules (fast throw-off, passive play in attack, 14 players in team...).
 - better defenses – it's very difficult to score a goal against formatted zone defense,
 - better and more appropriate physical (endurance, strength and power of players) technical and tactical preparation of the players,
 - introduction of new science based knowledge in the theory and practice of handball training,

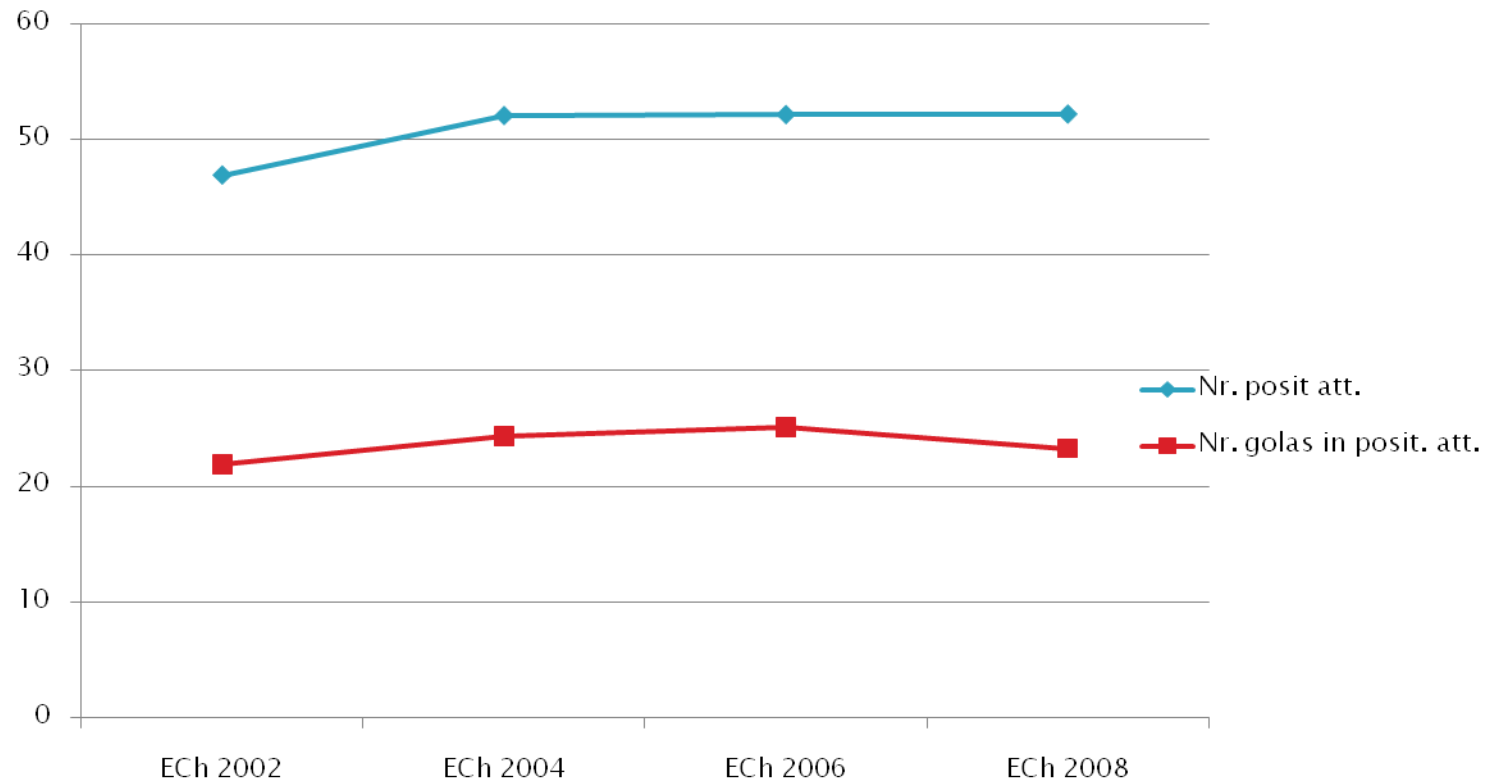
- demands of the spectators,
- great number of professional or almost professional clubs and national competitions.

- ▶ Some statistic data which illustrate this facts:
- ▶ **Number of attacks increased** (over 60 attacks per team in one match; WCh final match in Portugal 2003 GER – CRO – 61 per team),
- ▶ **More goals per match** (in average over 30 goals per team),
- ▶ **Shorter time of attack** (shorter preparation phase of attacks, slow attacks with many interruptions are out of trends),
- ▶ **More goals from counter attack** (Norwegian women team scored on average one third of all goals from counter attacks on ECh in Hungary 2004),
- ▶ **Approximately 60% of all attacks begin with a counter attack.**

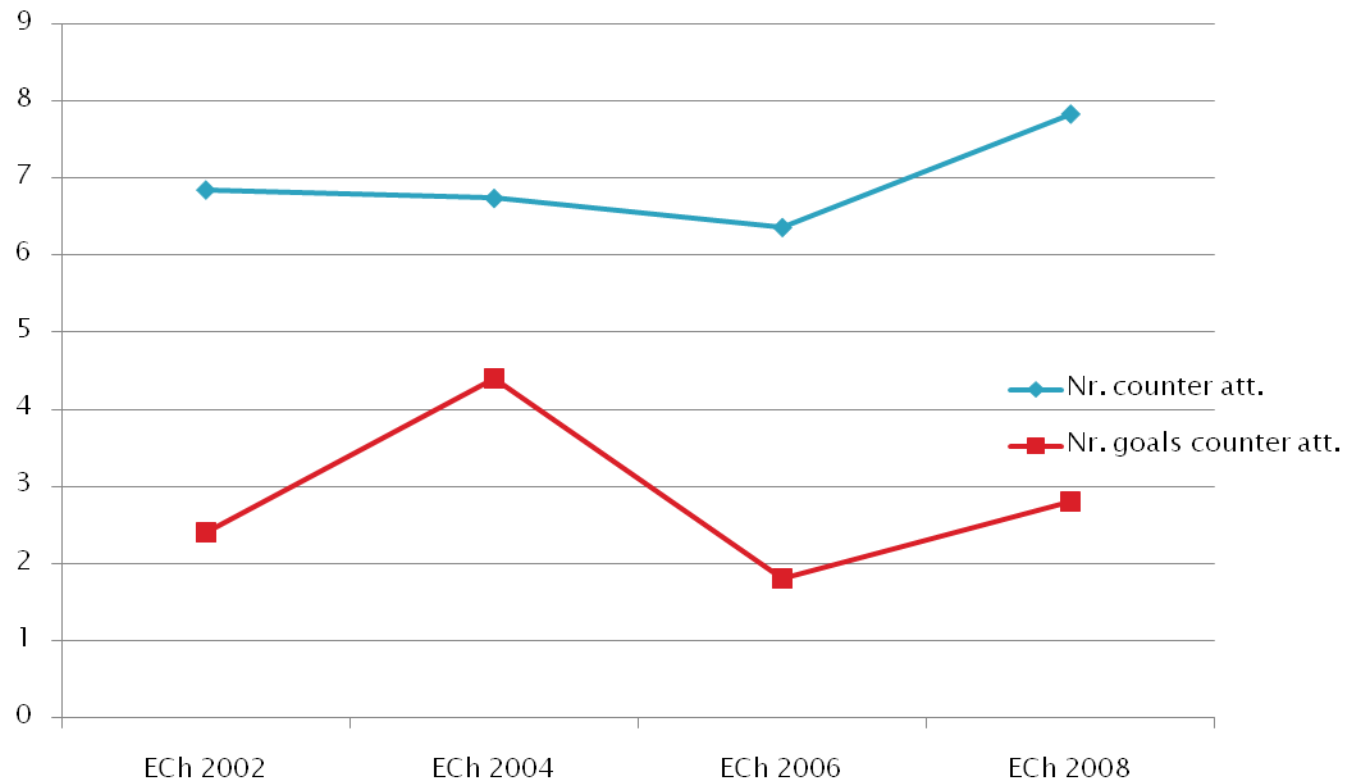
Average number of attacks, shots and goals per match and per team on the four consecutive Ech (Data source: official statistic of the Championships)



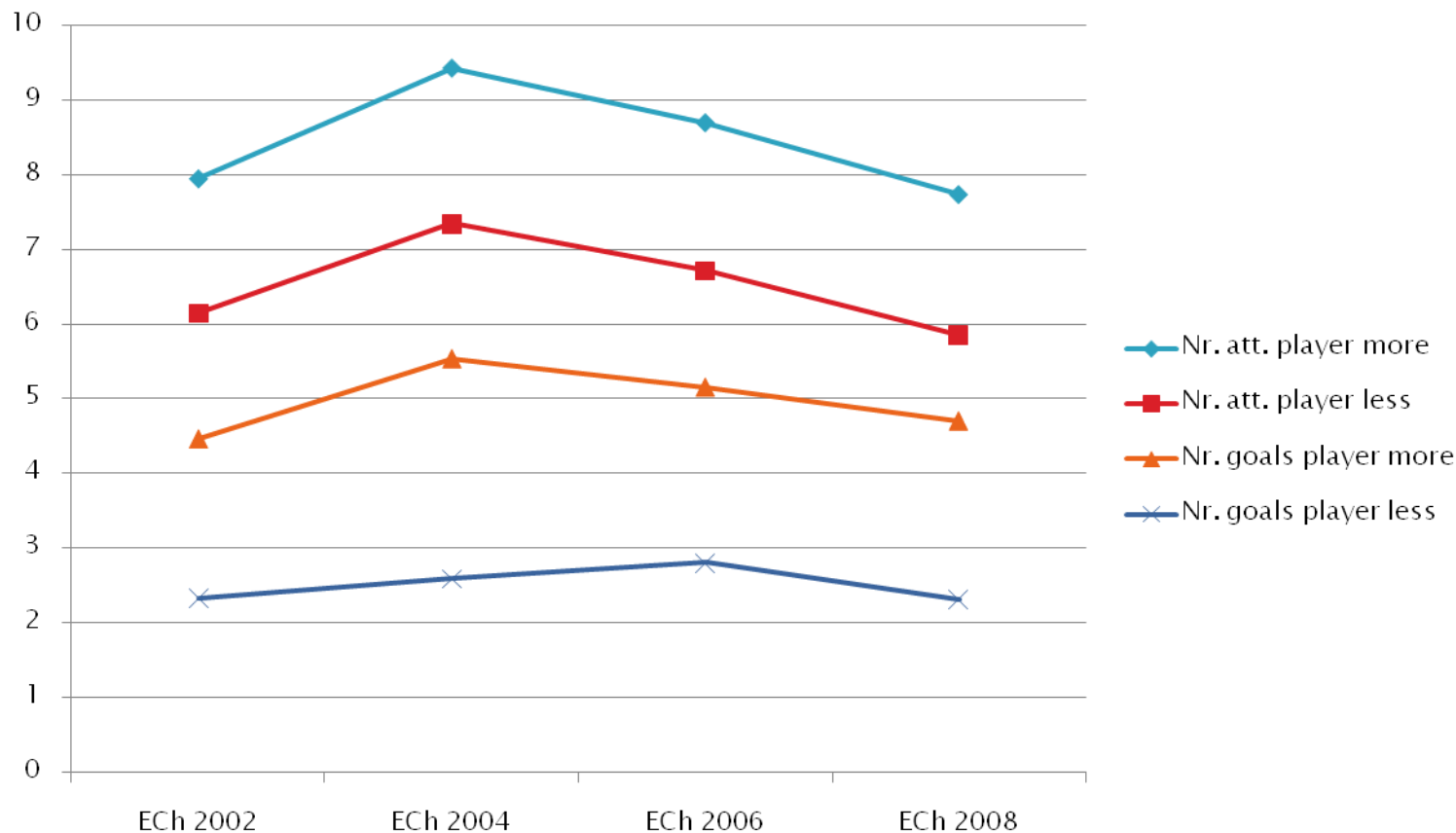
Average number of positional attacks and average number of goals from positional attacks



Average number of simple counter attacks and average number of goals from simple counter attacks

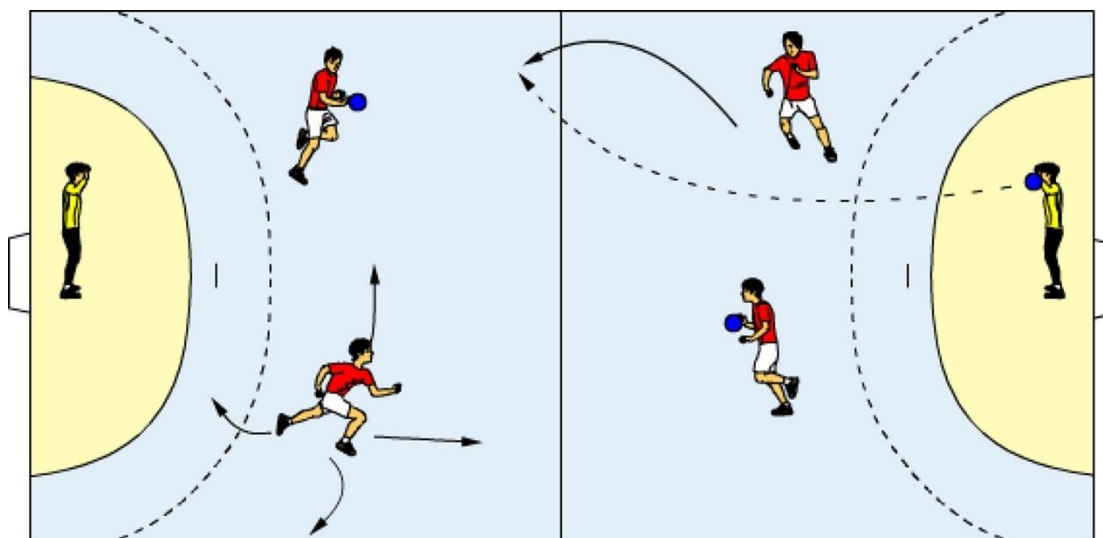


Average number of attacks with player more and less and average number of goals in attacks with player more and less



- ▶ Definitions:
- ▶ **Load**: means all those activities, that player execute during the match – intensity and duration,
- ▶ **Effort**: metabolic response to those actions and it's influence on the players ability to maintain or even raise the level of load.

- ▶ Load of handball players during the match should be divided into **cyclic** and **acyclic** activities,
- ▶ Cyclic movements are fundamental as they allow the player to move within the court in two dimensions (length and width). They include **walking** and **running** without a ball as well as dribbling the ball while walking or running.



- ▶ acyclic activities (passing the ball, shots, jumps, body contact with the opponent when breaking through, falls etc.) occur along with the player's cyclic movements (running, walking),
- ▶ in handball loading combines cyclic and acyclic activities and appears at **intervals**,
- ▶ the intensity and volume of loading in handball are very **heterogeneous** – it means that high or low intensity and large or small volume, alternates continuously with periods of relative rest i.e. standing or walking.

- ▶ The lack of useful data and the development of information and video technology raised up researchers interest to analyse the loading structure of an individual player and the team as a whole,
- ▶ It was presumed that such data could help coaches to optimise and control training activities.

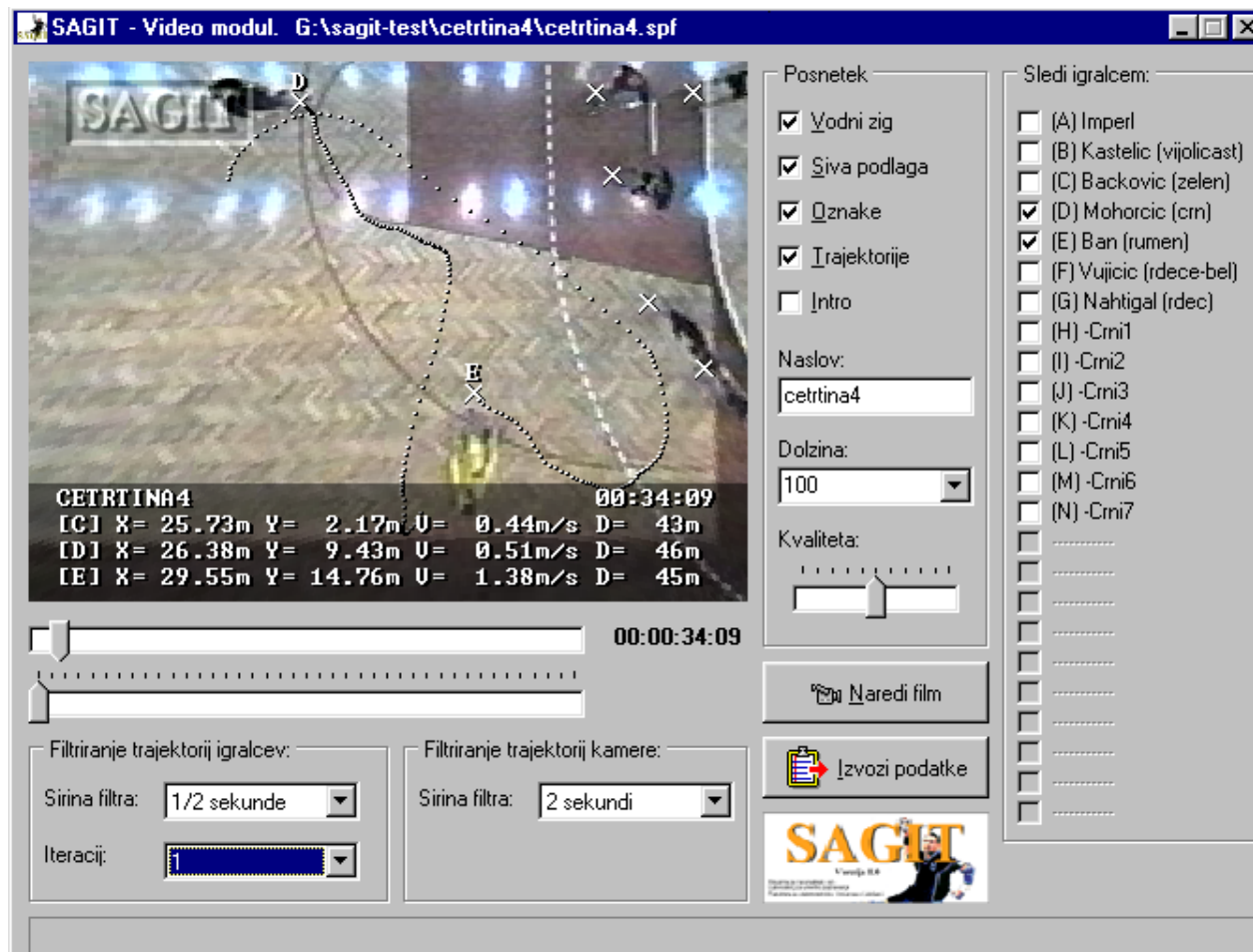
- ▶ Development of correct methodology:
- ▶ **SAGIT system** – (in collaboration between Faculty of Sport and Faculty of Engineering and computer sciences University of Ljubljana) – computer-supported automatic tracking method which is based on computer vision methods,
- ▶ SAGIT system essentially consists of several modules,

- ▶ the basic one is a module for the preparation of recording (video–recording), further analysis and tracking,
- ▶ the second one is an automatic tracker. The output data of the tracker are xy co–ordinates in the plane of the court for each or the selected player, which are used for further calculations,
- ▶ the last two modules are designed for calculating and displaying of results.

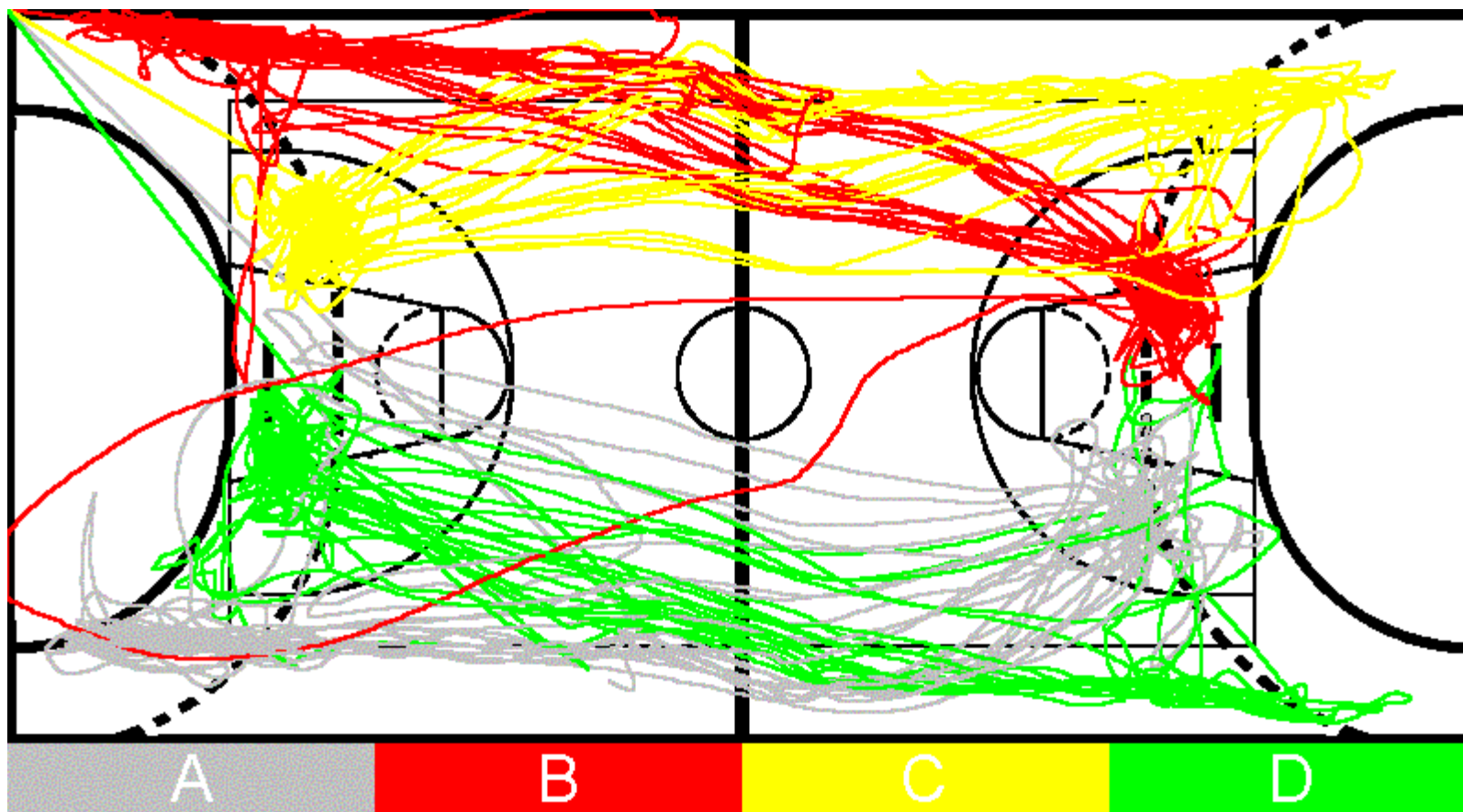
- ▶ Images are captured by two cameras placed directly above the court so that the optical axis of the camera and the court formed a right angle,
- ▶ the cameras were fixed while recording the match, each of them covering one half of the court. Their fields of vision partly overlapped which enabled tracking of players while crossing the centre of the court.

- ▶ The captured images are synchronised before processing so that at any time the tracker was able to produce images recorded by both cameras at the same moment.
- ▶ Measurement characteristics were determined and the system is considered as accurate and reliable (Perš, J. M. Bon, Kovačič, M. Šibila, B. Dežman (2002). Observations and analysis of large-scale human motion. Human Movement Science 21. 295–311),
- ▶ Main problem:
 - Complex and time-consuming work; (many operators interventions due to body contacts).





User interface of the module for displaying results. Player's current speed as well as walked or run distances is shown.



Movement patterns of the players

- ▶ First time we use the system to obtain the data for doctoral dissertation of M. Bon (Quantified Evaluation of Loading and Monitoring of Heart Rate of Handball Players in a Match, 2001).
- ▶ Model matches: one should limit unknown variables by prescribing the certain match conditions – standardization (no substitutions of players during the match, no team time-out, prescribed defence system);

Loads of players during the match were divided into:

Cyclic activities

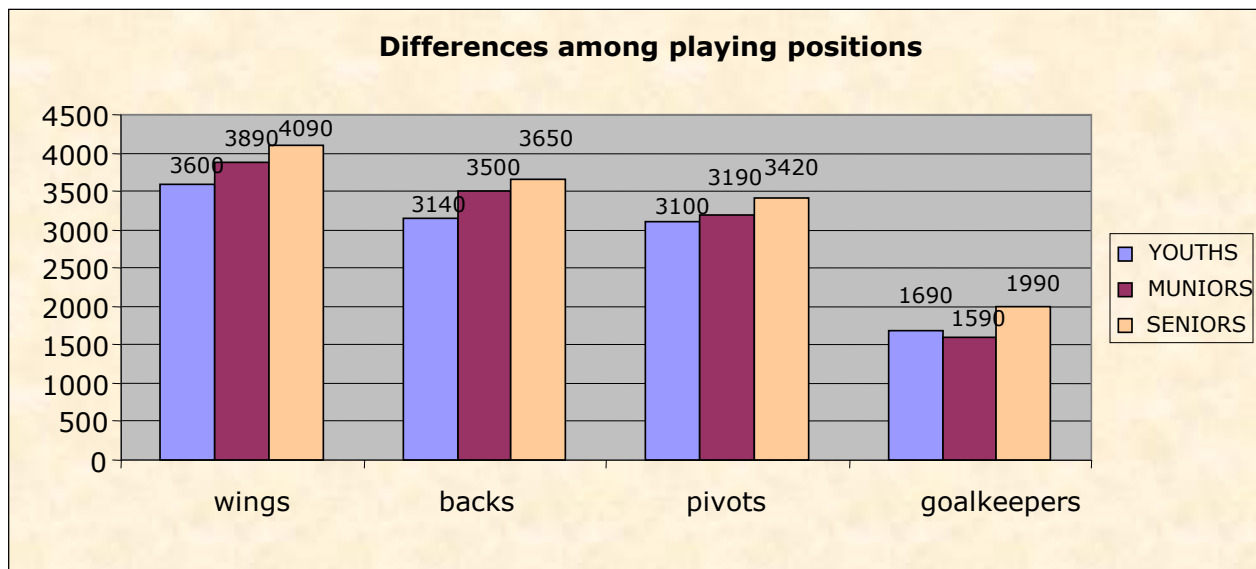
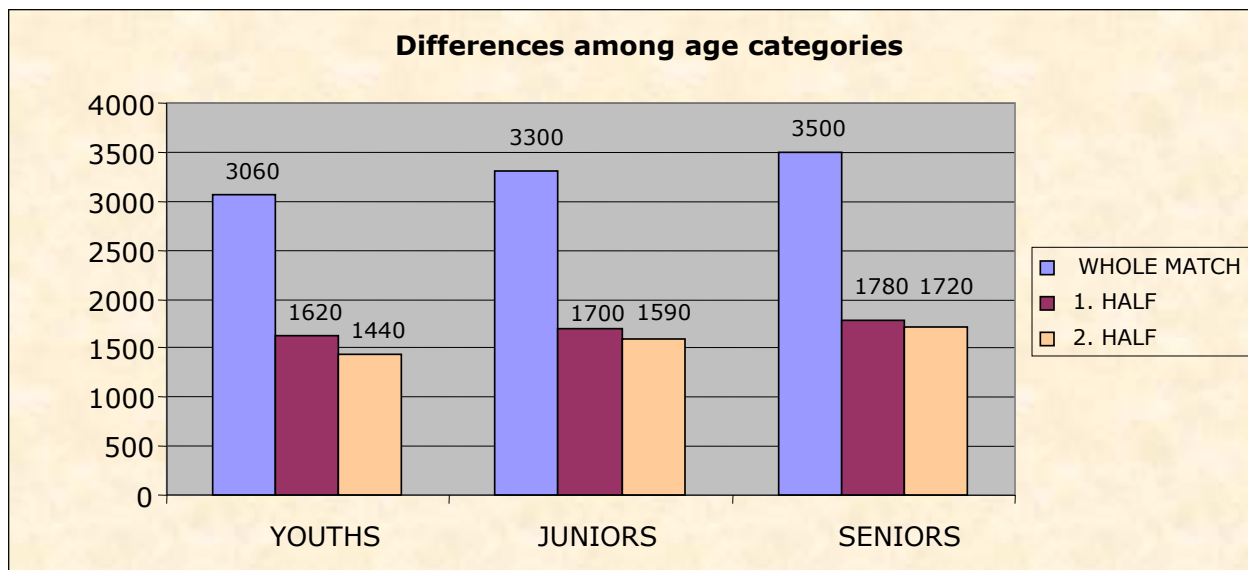
- **Volume**
 - Walking and running distances (m)
- **Intensity** – speed classes (SC)
 - 1SC – walking ($>5\text{km/h}$)
 - 2SC – jogging ($5\text{km/h} - 12\text{km/h}$)
 - 3SC – fast running ($12\text{km/h} - 18\text{km/h}$)
 - 4SC – sprinting ($<18\text{km/h}$)

Acyclic activities

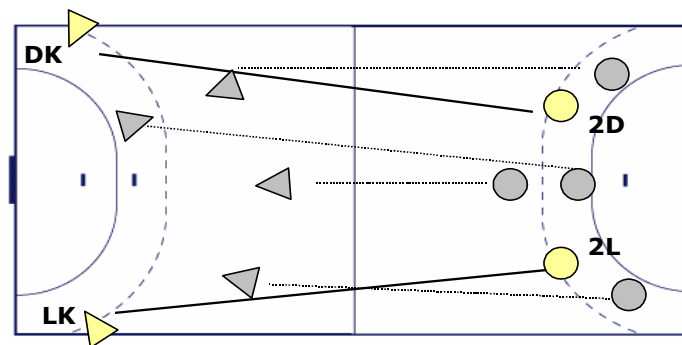
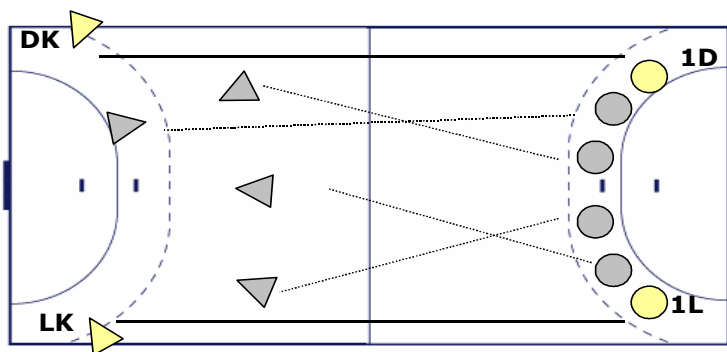
- Frequency of appearance (f)

- ▶ Sample of seven players, 1. division (match Slovan – Gorenje)
 - **most important results:**
 - ✓ average volume of cyclic movement: 4790 m.
- ▶ back players – 4600 m,
- ▶ wings – 4995 m,
- ▶ pivots – 4850 metrov.
- ▶ Second half – decrease of volume and intensity of cyclic activities (1 Half – 2560m, 2 half – 2230m)
 - ✓ 7 % of playing time players performed sprints,
 - ✓ 25 % – fast running,
 - ✓ 31 % – jogging,
 - ✓ 37 % – walking or stand still.

Pori (2001) – sample 84 players; different playing positions and age categories -
20 min. model matches.



- **Pori (2003)** – differences in two different match models - on one side team play 6:0 zone defence (wings 1L and 1R defender), on the other side team play 3:2:1 zone defence system (wings left and right defender);
- sample 12 wing players – juniors.



	volume	walking	jogging	fast run	sprint
z.d. 6:0	4880	1620	1450	1170	645
z.d. 3:2:1	5270	1400	1760	1540	558

- ▶ Next step – international level and real matches.
- ▶ WCh 2007 Germany – cyclic movement profile of (170 players (Dortmund & Mannheim hals)) – Authors: Platen/Luig 2008

Structure of cyclic movement load on the WCh 2007 Germany (Platen/Luig, 2008)

	walk	joging	Fast run	sprint	Midle speed	Nr. of sprints	Longest sprint	
Average of all	38,81%	42,61%	15,92%	2,66%	1,34m/s	33,8	9,31m	
Backs	34,00%	46,95%	16,85%	2,25%	1,46m/s (CB-1,50)	27,8	1H	2H
							7,62m	8,01m
Pivots	35,16%	45,25%	17,32%	2,27%	1,32m/s	31,2	6,72m	4,75m
Wings	35,15%	39,55%	20,16%	5,12%	1,38m/s	50,9	17,99m	14,87m
Goalke.	69,10%	–	–	–	0,80m/s	1,6	–	–

walk: 0,01–1,49m/s; jogging: 1,50–3,99m/s; fast run: 4,00–5,99m/s; sprint: >5,99m/s

	real distance	play time	distance/minute	expected distance/60 min.
all- average	2935,53m	32,11 min.	80,48m	4828,84m
backs	2839,90m	29,16 min.	87,86m	5251,60m
pivots	2786,92	29,37 min.	79,64m	4839,10m
wings	3710,61m	37,37 min.	83,19m	5081,80m
goalkeepers	2058,09m	37,11 min.	44,72m	2761,60m
central back	2757,62m	–	89,90	5394,03

- Particularities:
- Highest value of covered distance: 6443 m;
- Highest velocity of running: 8,7 m/s
- No decrease of running performance in 2. half

Woman's handball (Manchado, C., Frank, J. & P. Platen, 2008)

- ▶ Sample: 25 Norwegian and German players – international level

	covered distance	distance/min.	1 half/2half
field players	5251m	69,7m	71,5/65,2m
goalkeepers	2066	31.3m	–

Relationship low intensity/high intensity = 1/9.

Statistical significant difference between 1 and 2 half.

Acyclic activities (Pori, Mohorič, Šibila, 2009):

- ▶ Sample: 12 matches WCh 2007 Germany (4 matches from preliminary round, quarterfinal matches, half-final matches and both final matches).

	passes	shots	pistons	fall/raise	blockade	Uncovering	jumps
LW	36,2	6,2	7,8	2,4	0,3	8,0	5,3
LB	134,0	17,1	37,3	7,5	0,3	20,1	24,3
CB	177,1	10,8	44,1	6,1	2,5	22,1	12,8
RB	143,3	11,0	31,8	4,6	0,7	18,3	16,5
RW	48,5	8,3	10,7	3,9	0,5	11,5	8,5
P	35,7	6,6	0,5	8,1	27,2	20,0	5,1
Average	95,8	9,9	22,1	5,4	5,3	16,9	12,1

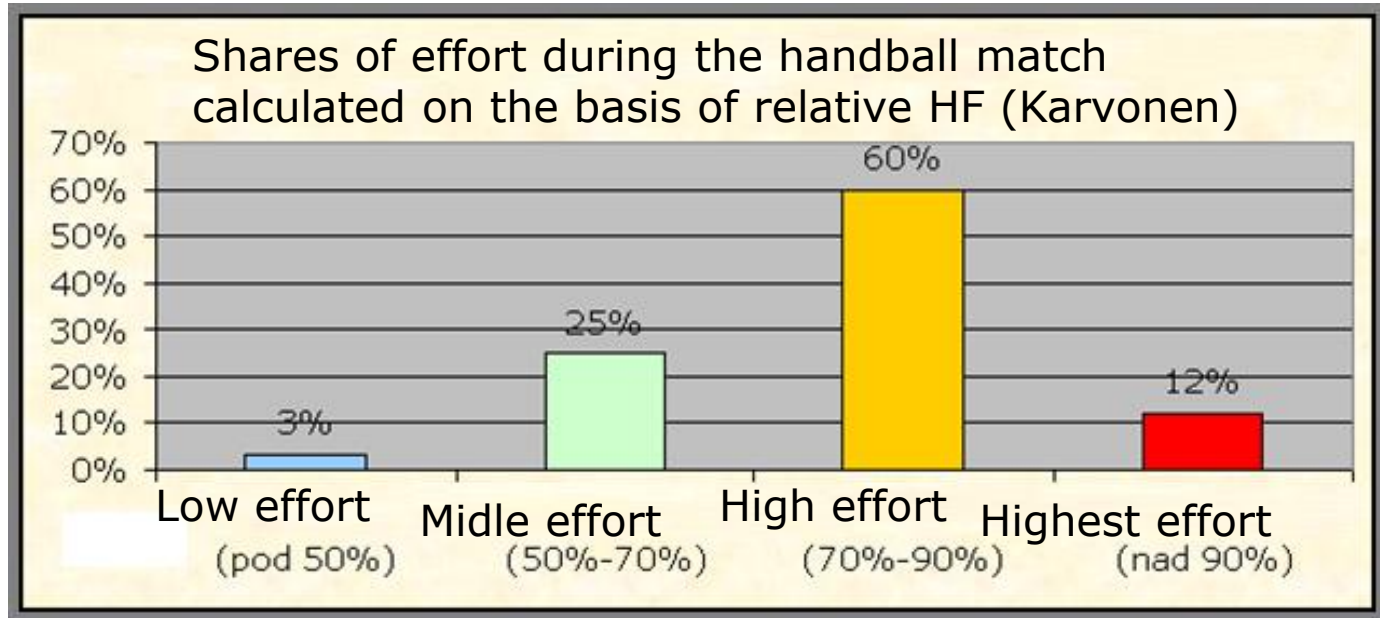
Effort in Handball

- ▶ Data about the Handball players load during the match represent only one part of information important for the trainings plan. Second part represent data about the players effort,
- ▶ cardio-vascular, nerve-muscle-tendon and other human systems response on a certain level of load. Indicators which shows the level of stress:

HANDBALL → HEART RATE (HR) and BLOOD LACTATE (LA)

- ✓ **RELATIVLY SIMPLE,**
- ✓ **GOOD ACCURACY OF MEASUREMENT,**
- ✓ **POSIBILITY OF MEASUREMENTS DURING THE MATCHES AND TRAININGS .**

Effort in Handball (Bon, 2001)



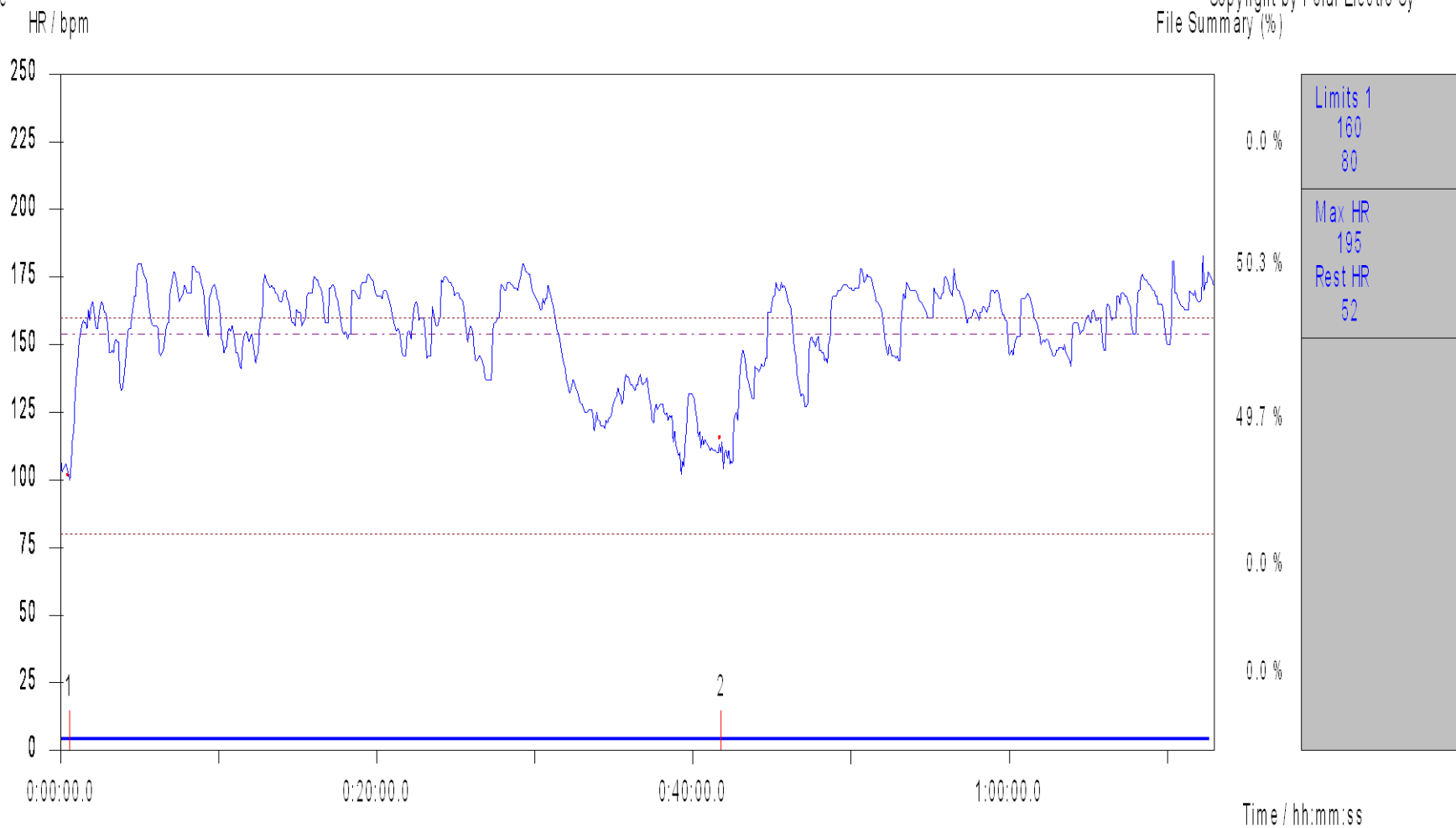
$$HF(\%) = [100 * (HF - HF_{min})] / [HF_{max} - HF_{min}]$$

Pori (2003) – 12 juniors wings

	HF – average (min., max.)	Blood lactat concentration – average
3:2:1		
1 half	166 (151,180) beats/min	4.8 mmol/l
2 half	157 (144, 172) beats/min	3.7 mmol/l
Whole match	161 beats/min	4.0 mmol/l
6:0		
1 half	158 (143, 171) beats/min	2.9 mmol/l
2 half	151 (135, 169) beats/min	2.5 mmol/l
Whole match	154 beats/min	2.7 mmol/l

Many more authors – similar values

Curve

Copyright by Polar Electro Oy
File Summary (%)

HR: 108

Time: 0:00:00.0

Person		Date	21.09.2002	Average	154 bpm	Recovery	-64 bpm
Exercise		Time	10:30:10.0	Duration of exercise: 1:12:57.9			
Note	KAVT_01			Selected period: 0:00:00.0 - 1:12:55.0 (1:12:55.0)			

- ▶ **HART FREQUENCY** – Interval between 120 and 200 beats/min. Average hart frequency during the match between 140 in 160 beats/min.
- ▶ **BLOD LACTAT CONCENTRATION** – Interval between 3 – 8 mmol/l. Doesn't exedeed 10 mmol/l (*400 m runners – 24 mmol/l*)
- ▶ very important is inteval "5% above and 5% below anaerobic threshold" – most playing time players are in this interval (reduction or decrease of activities).

Effort in Handball

WORK → ENERGY → **ATP** (high energy phosphate)



REPLENISHMENT OF ATP

- ✓ **ANAEROBIC ALACTIC ENERGY SYSTEM (ES),**
- ✓ **ANAEROBIC LACTIC ES,**
- ✓ **AEROBIC ES**

Energy source for replenishment of ATP (aerobic, anaerobic lactic or alactic) depends on intensity and duration of load.

Summary and application for the praxis:

Based on match analysis data we could say that during the activities characteristic for Handball match all three mechanisms for replenishment of the ATP are including:

ANAEROBIC ALACTIC ES.

Short sprints, jumps, shots, fast direction changing, ...

ANAEROBIC LACTIC ES

Long attacks, frequent body contacts with opponent, consecutive turnovers, high speed returning to defence after attack conclusion,...

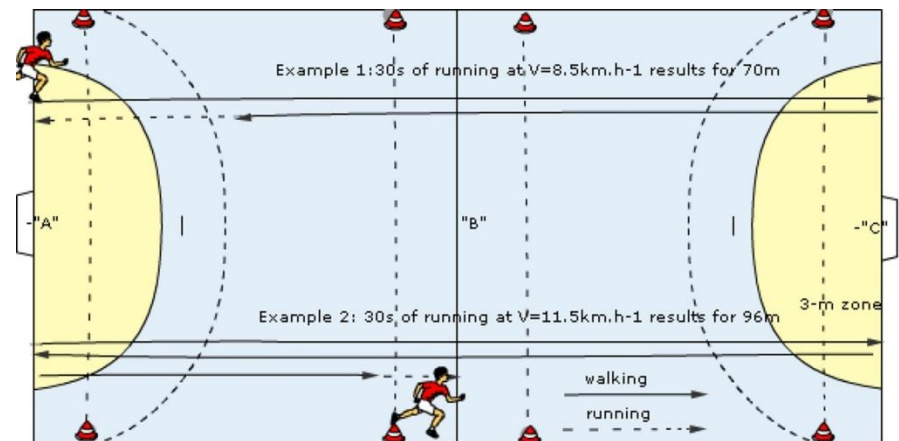
AEROBIC ES

Handball match lasts approx. 90 minutes.

Handball players are during the matches and trainings exposed both, high and low intensity, loads. Relationships between high and low intensity load on handball players depends on the type of the zone defence and the players' roles in the game, tactical requirements and individual characteristics of players. Loadings occur in irregular and unexpected intervals.

Testing of players endurance ability:

- ▶ Characteristic: progressive velocity, intermittent, changing of directions:
 - YO-YO intermittent test,
 - ISRT test,
 - “30-15_{IFT}” test.
 - hart rate at:
 - lactate threshold,
 - VO₂max.,
 - max. hart rate,
 - maximal velocity at the end of the Test.



Based on our findings we could prepare some instructions for handball players' conditioning, primarily from the point of view of cyclic loading:

- ▶ At least 3–4% of total time of training of handball players who take the positions of wings, back-court players and pivots (with individual unit usually lasting for 90 to 120 minutes) have to be accounted for by running with maximum intensity and at least 10–14% by running with medium intensity. From the point of view of cyclic activities the remaining time should be devoted to running with low intensity and walking or standing;
- ▶ naturally, the broad-brush sports training doctrine dealing with that loading which results from running with maximum intensity has to be considered within a micro cycle of various trainings

In view of the modern model of handball it may be concluded that:

- ▶ the time during which the players are subject to low-intensity loading has to be reduced (warming up!) and should only be used as relative break;
- ▶ the training methods have to include a large number of highly intensive activities of both cyclic and acyclic types;
- ▶ however, this doctrine has to change slightly, when it comes to goalkeepers. Compared to other groups of players goalkeepers perform a small volume of cyclic movements in a match. Therefore, it is more reasonable to include in goalkeepers' training a large volume of **acyclic activities**, inherent in their technique, than a large volume of cyclic activities.

For praksis...

**DATA ABOUT LOAD AND EFFORT DURING
THE MATCH**



**Training planing – SPECIFICITY
(as near as possible to handball match load
and effort)**



Physical conditioning training

For praxis.....

EFFECTIV TRAINING



**SPECIFIC INTERMITTENT HANDBALL EXERCISES,
WHERE ACTIONS WITH HIGH OR LOW INTENSITY AND
LARGE OR SMALL VOLUME, ALTERNATES
CONTINUOUSLY WITH PERIODS OF RELATIVE REST I.E.
STANDING OR WALKING**



**TAKE INTO CONSIDERATION RULES HOW INDIVIDUAL
ENERGETIC SYSTEMS SHOULD BE DEVELOPED**

EXAMPLES:

- ✓ *Long continuous runs in handball training!?*
- ✓ *100 m sprints!?*

ELABORATION OF SPECIFIC HANDBALL EXERCISES WHICH ARE PRESUMED TO HAVE INFLUENCE ON THE DEVELOPMENT OF SPECIFIC ES

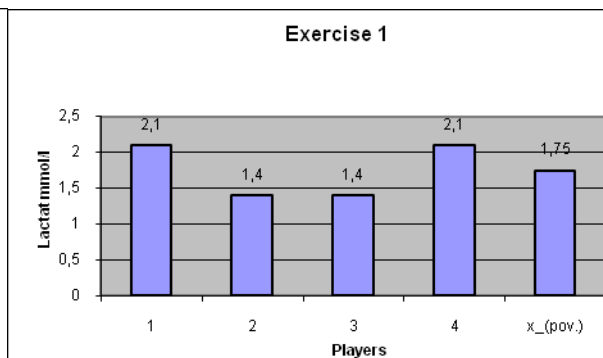
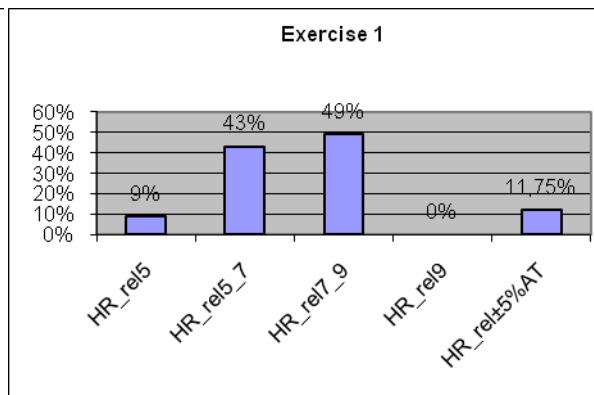
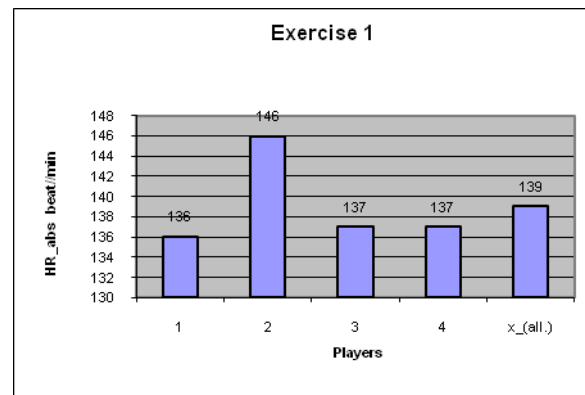
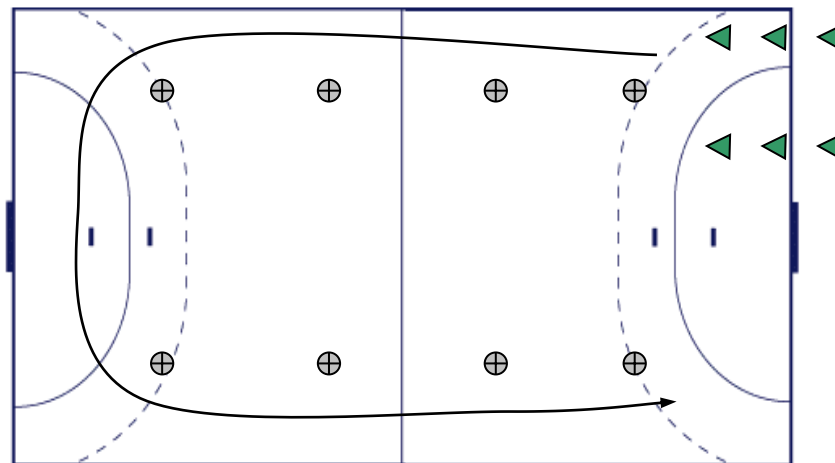
- 4 players who play on a different positions were measured on a handball training;
- 6 interval exercise were executed – situational handball exercises aimed to influence on the aerobic resistance;
- HR, blood lactate concentration and VO2max. were measured.

	HR_rest	HR_max	LA_rest	LA_max	VO2_max	AN_thres.	AN_thres.%
Player 1	46	188	1,1	8,8	57,06	177	92
Player 2	50	174	1,1	7,5	55,72	159	87,9
Player 3	50	192	1,1	6,5	58,98	162	78,9
Player 4	50	189	1,2	8,6	58,81	171	87
_(all.)	49	186	1,12	7,85	57,64	167,25	86,45

Basic physiological parameters obtained by laboratory measurements
(Nowatski protocol)

1. EXERCISE - Aerobic Handball poligon – 1.part

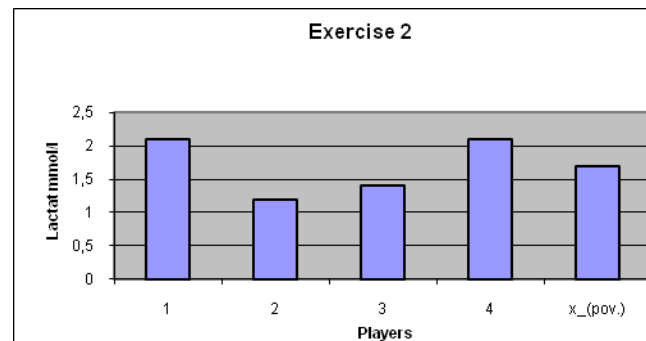
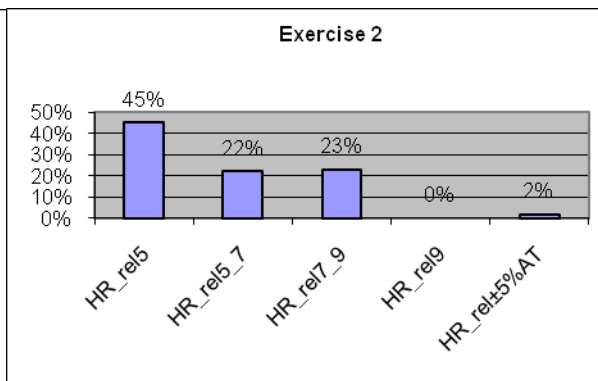
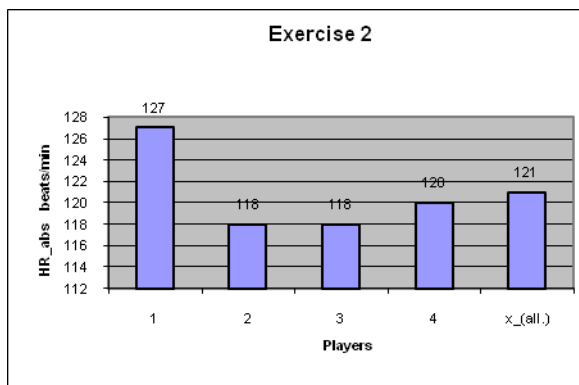
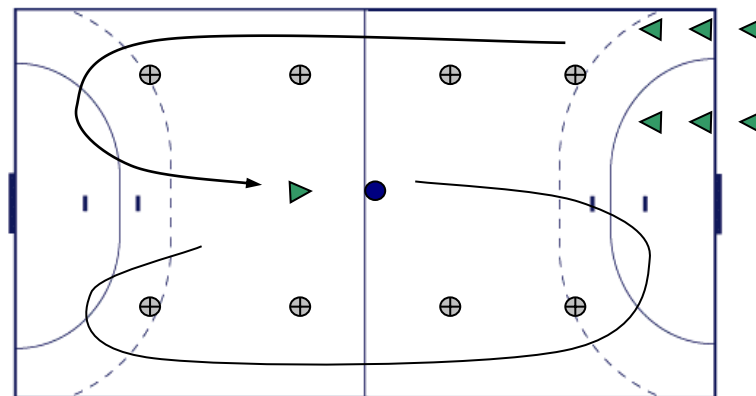
Duration of load:	10 min. (possible breaks)
Number of series:	1 to 3 (per training sesion)
Breaks between series:	2 to 3 min. (harte rate fall down)
Intensity:	Medium
Hart frequency:	120 – 150 beats/min



1. EXERCISE - Aerobic Handball poligon – 1.part (video)

2. EXERCISE - Aerobic Handball poligon – 2.part

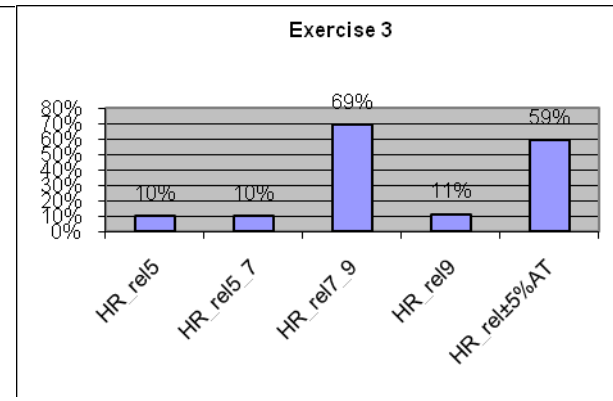
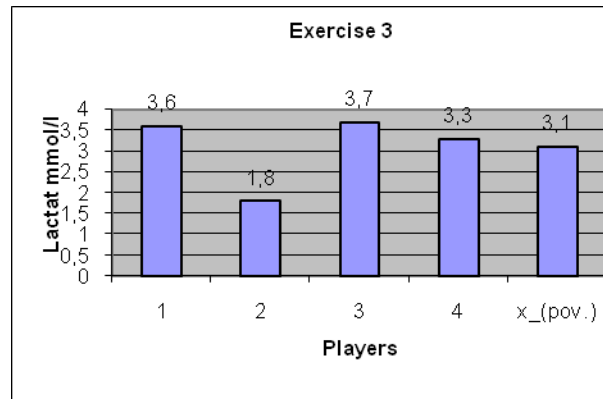
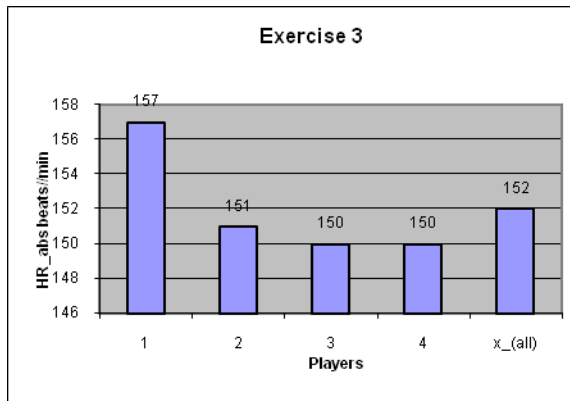
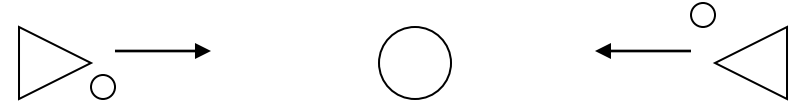
Duration of load:	3 min.
Number of series:	1
Breaks between series:	2 to 3 min. (harte rate fall down)
Intensity:	Medium
Hart frequency:	120 – 150 beats/min



2. EXERCISE - Aerobic Handball poligon – 2.part (video)

3. EXERCISE - High intensity defense movements in groups of three players

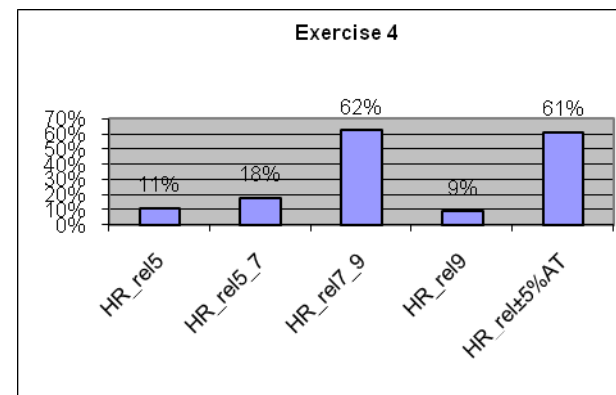
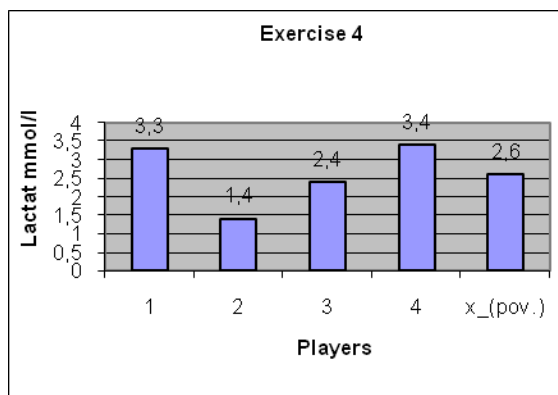
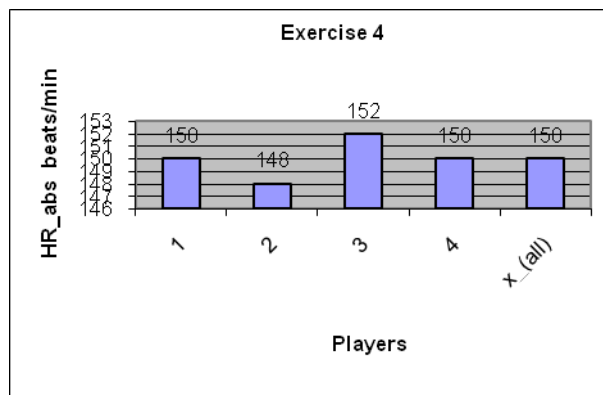
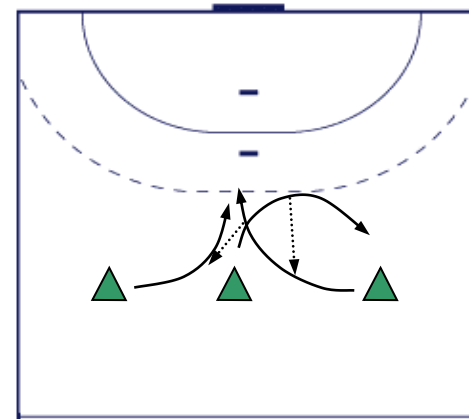
Duration of load:	6 min. / 30 s per repetition
Number of repetitions:	4 – for each one different task
Breaks between series:	60 s
Intensity:	High
Hart frequency:	120 – 150 beats/min



3. EXERCISE - High intensity defense movements in groups of three players (video)

4. EXERCISE - High intensity offence movements in groups of three players

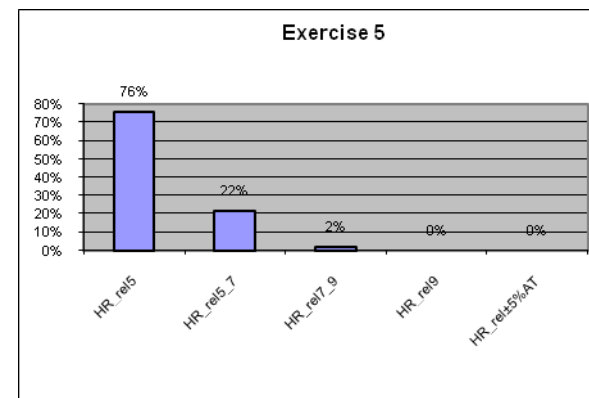
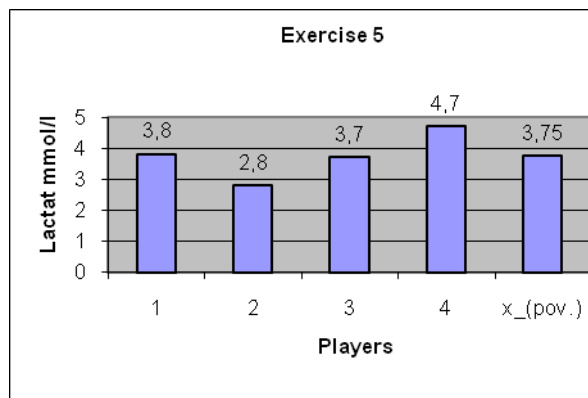
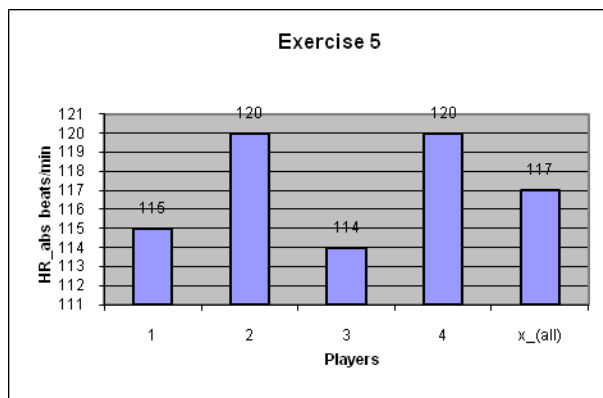
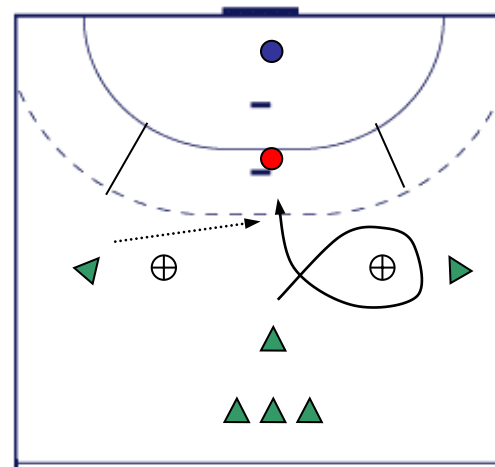
Duration of load:	2 min. / 15 s per repetition
Number of repetitions:	4
Breaks between repetitions:	15 s
Intensity:	High
Hart frequency:	140 – 160 beats/min



4. EXERCISE - High intensity offence movements in groups of three players (video)

5. EXERCISE - Central back shoots after running among the cons

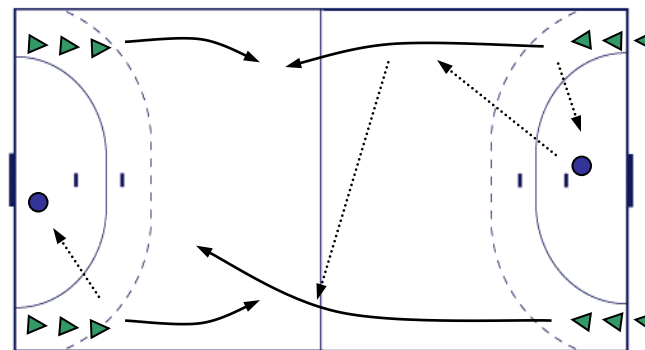
Duration of load:	40 s
Number of repetitions:	?
Breaks between repetitions:	?
Intensity:	High
Hart frequency:	140 – 160 beats/min



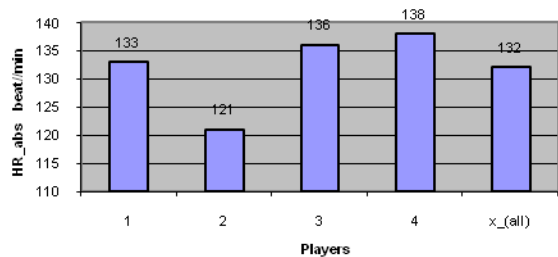
5. EXERCISE - Central back shoots after running among the cons (video)

6. EXERCISE - Counterattacks 2:2 with returning into defense

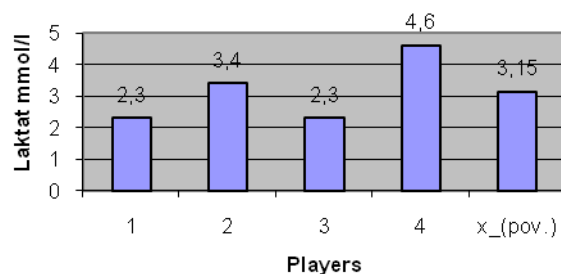
Duration of load:	3 min.
Number of repetitions:	4
Breaks between repetitions:	?
Intensity:	High
Hart frequency:	120 – 150 beats/min



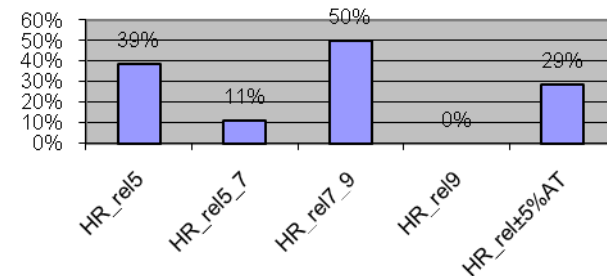
Exercise 6



Exercise 6



Exercise 6



6. EXERCISE - Counterattacks 2:2 with returning into defense (video)

Conclusion

- **Couch should always ask himself/herself about the efficiency and the aims of training and individual exercises. Basis are data of load and effort of the players during the match.**
- **Master Coach should have a knowledge about planning and execution a specific handball training in a holistic way. In every exercise beside technical and tactical aim he/she has to take into consideration also, physiological, psychological/sociological, ..., points of view.**
- **That is a modern approach in a training methodology and that leads to improvement and development of the players and the whole team.**

▶ THANK YOU VERY MUCH FOR YOUR
ATTENTION